DEPARTMENT OF THE ARMY TECHNICAL MANUAL

DEPARTMENT OF THE AIR FORCE TECHNICAL ORDER

TM 11-1167-20

TO 31P6-2TPS1-162

RADIO SET AN/TPS-1D

ORGANIZATIONAL MAINTENANCE

DEPARTMENTS OF THE ARMY AND THE AIR FORCE

MAY 1958

AGO 5676A—Apr

WARNING

DANGEROUS VOLTAGES EXIST IN THIS EQUIPMENT

Be careful when working on the 115-volt ac line connections or on the 300-volt circuits.

DON'T TAKE CHANCES!

EXTREMELY DANGEROUS VOLTAGES EXIST IN THE FOLLOWING UNITS:

Radar Receiver-Transmitter RT–212/TPS–1D	28,000 volts
Radar Modulator MD–212/TPS–1D	10,000 volts
Azimuth-Range Indicator IP–141/TPS–1D	5,000 volts
Power Supply PP–674/TPS–1D	450 volts
Antenna Base AB–221/TPS–1D	300 volts

GASOLINE HANDLING

Do not refuel the power unit and do not handle or leave open gasoline containers or plastic gasoline containers in the vicinity of the radar set while the radar transmitter is on (par. 58, TM 11–1167–10).

RF BURNS

Do not stand in front of the radiating horn while the radar set is transmitting.

TECHNICAL MANUAL
No. 11–1167–20
TECHNICAL ORDER
No. 31P6–2TPS1–162

DEPARTMENTS OF THE ARMY
AND THE AIR FORCE

WASHINGTON 25, D. C., *20 May 1958*

RADIO SET AN/TPS–1D

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*** This manual supersedes so much of TM 11–1167, 1 February 1954, including C 1, 27 June 1955, as pertains to organizational maintenance.**

CHAPTER 1
INTRODUCTION

1. Scope

a. These instructions are published for the use of personnel responsible for the organizational maintenance of Radio Set AN/TPS–1D.

b. This manual contains instructions for installation alinement and adjustment procedures, performing preventive maintenance, lubrication, troubleshooting, replacement of parts, and alinement and adjustment of equipment for second echelon level of maintenance. It also presents the basic theory of operation and provides a list for checking the performance of the equipment. The last chapter covers shipping, limited storage, and demolition of the equipment to prevent enemy use. Appendix I contains a list of pertinent references.

c. The basic issue list items that comprise a complete operating equipment, including running spares and accessories, are included in DA Supply Manual SIG 7 & 8 AN/TPS–1D.

d. Forward all comments concerning this manual to the Commanding Officer, United States Army Signal Publications Agency, Fort Monmouth, N. J.

2. Forms and Records

a. Unsatisfactory Equipment Reports.

(1) Fill out and forward DA Form 468 (Unsatisfactory Equipment Report) to Commanding Officer, Signal Equipment Support Agency, Fort Monmouth, N. J., as prescribed in AR 700–38.

(2) Fill out and forward AFTO Form 29 (Unsatisfactory Report) to the Commander, Air Materiel Command, Wright-Patterson Air Force Base, Ohio, as prescribed in AF TO 00–35D–54.

b. Damaged or Improper Shipment Report. Fill out and forward DD Form 6 (Report of Damaged or Improper Shipment) as prescribed in AR 700–58 (Army); Navy Shipping Guide, Article 1850–4 (Navy); and AFR 71–4 (Air Force).

c. Preventive Maintenance Form. Prepare DA Form 11–238 (Maintenance Check List for Signal Equipment, Sound Equipment, Radio, Direction Finding, Radar, Carrier, Radiosonde and Television) (figs. 1 and 2) in accordance with instructions on page 1 of the form.

ADDITIONAL ITEMS FOR 2D AND 3D ECHELON INSPECTIONS	CONDITION
26. INSPECT ANTENNA FOR ECCENTRICITIES, CORROSION, LOOSE FIT, DAMAGED ~~INSULATORS AND~~ REFLECTORS. PAR. 19b	✓
27. CHECK FOR NORMAL OPERATION. PAR. 19b	✓
28. ~~BEFORE SHIPPING OR STORING, REMOVE BATTERIES~~	

IF DEFICIENCIES NOTED ARE NOT CORRECTED DURING THE INSPECTION, INDICATE ACTION TAKEN FOR CORRECTION.

MAINTENANCE CHECK LIST FOR SIGNAL EQUIPMENT
SOUND EQUIPMENT, RADIO, DIRECTION FINDING RADAR, CARRIER, RADIOSONDE AND TELEVISION
(AR 750-625)

EQUIPMENT NOMENCLATURE: RADIO SET AN/TPS-1D

EQUIPMENT SERIAL NUMBER: 100

INSTRUCTIONS

This form may be used for a period of one month by using the correct dates and weeks of the month. It is to be used as a Preventive Maintenance check list for Signal equipment in actual use, or for a check on equipment prior to issue.

1. For detailed Preventive Maintenance instructions see:
   a. The Technical Manual *(in TM 11 series)* for the equipment. *(See DA Pamphlet Number 310-4)*
   b. The Supply Bulletin *(SB 11-100 series)* for the equipment. *(See DA Pamphlet Number 310-4)*
   c. The Department of the Army Lubrication Order. *(See DA Pamphlet Number 310-4)*

2. The following action will be taken by either the Communications Officer/ Chief for 1st echelon, or the Inspector for higher echelon:
   a. Enter Equipment Nomenclature and Serial Number.
   b. Strike out items that do not apply to the equipment.

3. Operator/Inspector will enter in the columns entitled CONDITION, on the proper line, a notation regarding the condition, using symbols specified under LEGEND.

4. After operator completes each daily inspection he will initial over the appropriate dates under "Daily Condition for Month", then return form to his supervisor.

FOLD

TYPE OF INSPECTION

OPERATOR	2/3 ECHELON	DATE	SIGNATURE
	✓	7Oct 57	John Doe
	✓	14Oct 57	William Smith
	✓	21Oct 57	John Doe
	✓	28Oct 57	William Smith

4

DA FORM 1 MAY 57 11-238

REPLACES DA FORMS 11-238, 1 NOV 55; 11-239, 11-244, 11-245, 11-248, 11-249, 11-250, AND 11-251; WHICH ARE OBSOLETE.

TM1167-20-1

Figure 1. DA Form 11–238, pages 1 and 4.

LEGEND for marking conditions:
Satisfactory, ✓.
Adjustment, Repair or Replacement required, X.
Defect corrected, (X).

DAILY CONDITION FOR MONTH OF OCTOBER, 1957

NO.	DAILY ITEM	1 17	2 18	3 19	4 20	5 21	6 22	7 23	8 24	9 25	10 26	11 27	12 28	13 29	14 30	15 31	16	2D 3D ECHELON
1.	COMPLETENESS AND GENERAL CONDITION OF EQUIPMENT. *(Transmitter, receiver, carrying cases, wire, cables, ~~microphones~~, tubes, spare parts, technical manuals).* PAR.19b																	✓
2.	CLEAN DIRT AND MOISTURE FROM ANTENNA, ~~MICROPHONES, HEADSETS, KEYS~~, JACKS, PLUGS, COMPONENT PANELS. PAR.19b																	✓
3.	INSPECT CONTROLS FOR NORMAL OPERATION. TAP CONTROLS LIGHTLY FOR EVIDENCE OF CUT-OUT FROM LOOSE CONTACTS.																	✓
4.	~~CHECK FOR NORMAL OPERATION OF EQUIPMENT. BE ALERT FOR UNUSUAL OPERATION OR CONDITION.~~																	

WEEKLY	CONDITION EACH WEEK 1ST	2D	3D	4TH	5TH	2D 3D ECH
5. CLEAN AND TIGHTEN EXTERIORS OF CASES, ~~RACKS~~, MOUNTS, TRANSMISSION LINES. PAR.19b	✓	✓	✓	✓		✓
6. INSPECT CASES, MOUNTS, ANTENNA TOWERS AND EXPOSED METAL SURFACES FOR RUST, CORROSION. PAR.19b						✓
7. INSPECT CORDS, CABLE, WIRE, ~~SHOCK MOUNTS~~ FOR CUTS, KINKS, BREAKS, FRAYING, UNDUE STRAIN. PAR.19b						✓
8. CHECK ~~ANTENNA~~ GUY WIRES FOR PROPER TENSION OR DAMAGE. PAR.19b	✓	✓	✓	✓		✓
9. INSPECT CANVAS ~~AND LEATHER~~ ITEMS FOR MILDEW, TEARS, FRAYING.						✓
10. INSPECT ACCESSIBLE ITEMS FOR LOOSENESS: SWITCHES, KNOBS, JACKS, CONNECTORS, RELAYS, TRANSFORMERS, MOTORS, PILOT LIGHTS, BLOWERS, ETC.						✓
11. CLEAN AND/OR INSPECT AIR FILTERS, BRASS NAME PLATES, DIAL AND METER WINDOWS. PAR.19b						✓
12. ~~INSPECT STORAGE BATTERIES FOR DIRT, LOOSE TERMINALS, SPECIFIC GRAVITY, DAMAGED CASES. INSPECT DRY BATTERIES FOR LEAKAGE.~~						

ADDITIONAL ITEMS FOR 2D AND 3D ECHELON INSPECTIONS	CONDITION
13. INSPECT SHELTERS AND COVERS FOR ADEQUACY OF WEATHER-PROOFING, TEARS, FRAYING. PAR.19b	✓
14. ~~CHECK TERMINAL BOX COVERS FOR CRACKS, DIRT, LEAKS, DAMAGED GASKETS, GREASE.~~	

ADDITIONAL ITEMS FOR 2D AND 3D EC HELON INSPECTIONS	CONDITION
15. INSPECT SEATING OF READILY ACCESSIBLE PLUCK-OUT ITEMS: ~~TUBES~~, LAMPS, FUSES, ~~CRYSTALS~~, CONNECTORS, ~~VIBRATORS, PLUG-IN COILS~~. PAR.19b	✓
16. INSPECT RELAYS ~~AND CIRCUIT BREAKERS~~ FOR LOOSE MOUNTINGS, BAD CONTACTS, MIS-ALINEMENT OF CONTACTS AND SPRINGS, PROPER SPRING TENSION. PAR.19b	✓
17. ~~INSPECT VARIABLE CAPACITORS FOR DIRT, MIS-ALINEMENT OF PLATES, LOOSE MOUNTINGS, MOISTURE.~~	
18. INSPECT RESISTORS, BUSHINGS AND INSULATORS FOR CRACKS, CHIPPING, BLISTERING, MOISTURE, DISCOLORATION. PAR.19b	✓
19. CLEAN AND TIGHTEN SWITCHES, TERMINAL BLOCKS, BLOWERS, RELAY CASES AND INTERIORS OF CHASSIS AND CABINETS NOT READILY ACCESSIBLE. PAR.19b	✓
20. INSPECT TERMINAL BLOCKS FOR LOOSE CONNECTIONS, CRACKS AND BREAKS. PAR.19b	✓
21. INSPECT TERMINALS OF LARGE FIXED CAPACITORS AND RESISTORS FOR DIRT, CORROSION, LOOSE CONTACTS. PAR.19b	✓
22. INSPECT TRANSFORMERS, CHOKES, POTENTIOMETERS AND RHEOSTATS FOR OVERHEATING AND OIL LEAKAGE. PAR.19b	✓
23. INSPECT GENERATORS, ~~AMPLIDYNES, DYNA~~. MOTORS FOR BRUSH WEAR, SPRING TENSION, ARCING AND FITTING OF COMMUTATOR.. PAR.19b	✓
24. INSPECT CATHODE RAY TUBES FOR BURNT SCREEN SPOTS.	✓
25. INSPECT WATERPROOF GASKETS FOR LEAKS, WORN OR LOOSE PARTS. PAR.19b	✓

CONTINUED ON PAGE 4

2 3

GPO: 1957 O—427034

TM1167-20-22

Figure 2. DA Form 11–238, pages 2 and 3.

CHAPTER 2
INSTALLATION ALINEMENT AND ADJUSTMENT PROCEDURES

3. General

This chapter covers alinement and adjustment procedures that must be performed on Radio Set AN/TPS–1D after installation (pars. 22–48, TM11–1167–10) and prior to initial operation of the equipment. Some of these adjustments also are made periodically during operation (pars. 49–70, TM 11–1167–10). Before attempting to aline the equipment, read carefully all the alinement procedures given in this chapter. Performing the alinement and adjustment procedures in haphazard sequence may result in serious damage to the set; therefore, perform the procedures in the order in which they are presented. Be sure to make all the initial checks (par. 6) before applying power to the set.

a. Disabling Interlocks. Procedures for disabling interlocks when a unit is opened are explained in (1) through (6) below. All interlocks, if disabled, are automatically restored to normal condition when the units are closed. High-voltage warning lights are illuminated in Radar Modulator MD–144/TPS–1D (figs. 8 and 27), the indicator (fig. 13), Power Supply PP–674/TPS–1D (fig. 31) and Radar Receiver-Transmitter RT–212/TPS–1D (figs. 3 and 34) when the interlocks are disabled and primary power is present.

Warning: If an interlock is disabled, avoid direct contact with all circuits. If possible, keep out of direct contact with ground. This equipment employs lethal voltages.

(1) *Modulator.* To disable interlock S153 and the shorting switch, hinge the interlock disabling lever on the lower right side of the chassis outward so that the lever is at right angles to the side of the chassis (fig. 8).

(2) *Indicator.* To disable interlock S603, located on the rear upper left edge of the chassis, pull outward on the interlock pin after centering the pin in its bracket. A tapered recess in the pin holds the pin in the outward position (fig. 23).

(3) *Signal comparator.* To disable blower motor interlock S2355, located on the rear center edge of the chassis, pull outward on the interlock pin after centering the pin in its bracket. A tapered recess in the pin holds the pin in the outward position (fig. 22).

(4) *Power supply.* To disable interlock S402, push INTERLOCK SHORTING SWITCH S404, located on the top left front corner of the chassis (fig. 31), to the rear.

(5) *Receiver-transmitter.* To disable interlock S504, accessible through an opening in the upper right side of the chassis, push in on the interlock extension shaft push rod (upper right rear corner of the chassis), and press the locking pin (pin on lower side of S504 rocker arm). Release pressure on the extension shaft and then release pressure on the locking pin (fig. 3). To disable interlock S504, using an alternate procedure, push in on the roller end of the S504 rocker arm, accessible through the opening in the upper right side of the chassis, and press the locking pin on the opposite end of the arm. Then release the roller end of the rocker arm and release pressure on the rocker arm pin.

(6) *Servo amplifier (antenna base).* To disable interlock S701 (fig. 11), located on the rear edge of the chassis, push in on the roller end of the S701 rocker arm, press the locking pin on the opposite end of the arm, release the roller end of the rocker arm, and then release pressure on the rocker arm pin.

b. Disabling Antenna Base AB–221/TPS–1D. To disable the antenna base, snap safety switch

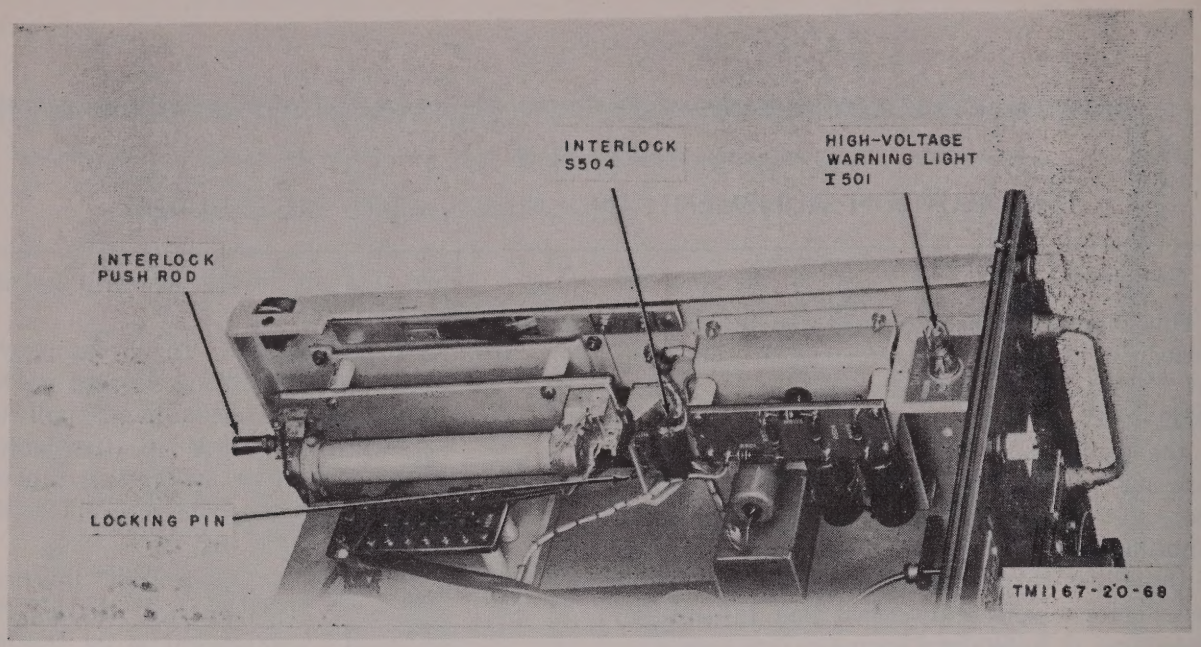


Figure 3. Receiver-transmitter interlock and warning light.

S753 (fig. 8, TM 11–1167–10), located on the small rectangular panel just above and to the right of the servo amplifier panel, to OFF. The antenna cannot be rotated when the safety switch is in the OFF position.

Caution: Damage to the drive assembly gears may result if the safety switch is operated while the antenna is rotating.

c. Use of Telephone Circuit. At remote installations of the antenna and/or the indicator, it is convenient to use the telephone circuit for communication during installation alinement and adjustment. Sound powered telephones with ¼-inch diameter tip and sleeve plugs (par. 16*d*, TM 11–1167–10) are required. PHONE jacks are located on the power supply (fig. 56, TM 11–1167–10), the antenna base (fig. 8, TM 11–1167–10), and the indicator (fig. 55, TM 11–1167–10).

d. Use of Convenience Outlets. Three convenience outlets (115 volts at 400 cycles) are provided on the radar set. They are located on the power supply (fig. 56, TM 11–1167–10), the antenna base (fig. 8, TM 11–1167–10), and the indicator (fig. 55, TM 11–1167–10). They are provided for the use of soldering irons, test equipment, trouble lights, etc. When the equipment is not radiating, the convenience outlet circuit is fused for 6.25 amperes. When the equipment is radiating, the outlet circuit is fused for 1.6 amperes.

4. Tools and Test Equipment Required

Tools and test equipment required for checking, alining, and adjusting Radio Set AN/TPS–1D are listed below. The tools and materials contained in Tool Equipment TE–113 are listed in Supply Manual SIG 6 TE–113. Special tools and test equipment are listed in paragraph 5.

a. Tools. One Tool Equipment TE–113 is required.

b. Test Equipment.

Nomenclature	Common name	Manual
Multimeter TS–352B/U	Multimeter	TM 11–5527A
Variable Power Transformer TF–171/USM.	Variac*	TM 11–1250
Test Set TS–172A/UP	Echo box	TM 11–1262
Summation Bridge AN/URM–23.	Summation bridge.	TM 11–5128
Signal Generator TS–419/U.	Uhf signal generator.	TM 11–5553

* Electrical Power Cable Assembly CX–3641/U must be attached to the variac (fig. 7).

5. Special Tools

Special tools, in addition to the tools listed in

paragraph 4*a*, are required to aline and adjust the radar set. The items and functions are listed below.

a. Leveling rod (jack tool) for leveling tower (fig. 25, TM 11–1167–10).

b. Strap wrench (fig. 19) for tightening knurled fittings. Figure 22, TM 11–1167–10 shows it being used in conjunction with tower assembly tool.

c. Mirror assembly (fig. 19), which is clamped around the bezel of the A scope (fig. 59, TM 11–1167–10), to facilitate the viewing of scope patterns when adjusting the radar system.

6. Initial Checks

The following checks are necessary to be sure the installation is complete and accurate and that no damage to the equipment or danger to personnel will result when the power is first applied. In addition, it is necessary to check the condition of items that may have been damaged prior to the initial checks.

a. External Tower Checks.

(1) Check the adequacy of the supporting ground or structure, especially at a remote antenna installation.

Note. Weight of each unit is shown in paragraph 5, TM 11–1167–10.

(2) Check jacks on Mounting MT–960/TPS–1D (fig. 10, TM 11–1167–10) for proper weight distribution as follows:

(*a*) Turn jacks at all four corners to check weight distribution. Use jack tool.

(*b*) Equalize weight by response to turning effort. Be sure to check the level during this procedure ((6) below).

(3) Check the seating of the interunit captive locking pins (24) located at unit corner posts.

(4) Check the seating of guy anchors. If there are any signs of movement, have the anchors reset.

(5) Check the tower guy cables for just enough tension to keep the tower steady. Make certain that all cable fittings are tight.

(6) Check the level of the tower by the indication on the spirit level mounted on the frame of Antenna Base AB–221/TPS–1D (fig. 8, TM 11–1167–10).

(7) Check the security of the electrical ground stake, the ground cable connections to the ground stake and bottom of Radar Modulator MD–144/TPS–1D, and the interunit straps.

Note. At a remote antenna installation, check for attachment of a ground lead (No. 10 wire size minimum) to the antenna base.

(8) Check the antenna reflector sections for a downward position of the black edges and tighten the hand screws. To gain access to the antenna in a single-stack installation, proceed as explained below. Reverse the procedure when the inspection has been completed (fig. 32, TM 11–1167–10).

(*a*) Loosen the ropes attached to the four corners and sides of the tent fly so that it may be pulled upward to the bottom of the antenna.

(*b*) Climb the tower and unfasten the zipper on the entrance side of the tent. Also unfasten the two adjacent zippers at the top of the antenna base unit.

(*c*) Pull out the aluminum tent retaining rod (on the entrance side) which secures the top of the tent to the antenna base unit.

(*d*) Pull up the fly.

(9) Check for scratches, that expose the bare metal, in metal parts exposed to the elements.

(10) Check all cables for proper placement, mating, and security. Compare reference designation on cable bands with reference designations on identification plates for unit jack fittings. Refer to the interunit cabling diagram (fig. 52, TM 11–1167–10). Be sure that the system power in cable W15 is connected to a 115-volt, 400-cycle source. If a remote plan position indicator is being used, check for connections to J412, J414 and J419 on the power supply (fig. 50, TM 11–1167–10).

(11) Check rigid coaxial sections (fig. 17, TM 11–1167–10) for tight connections. Use the strap wrench, which is con-

tained in Case CY–1060/TPS–1D (fig. 11, TM 11–1167–10), to tighten the knurled fittings of RF 851 and RF 855.

Caution: Tighten RF 851 and RF 855 carefully if fittings are not sufficiently tight. Too tight a fit may cause damage at a connection.

(12) Check for missing blown fuse indicator lamps on the front of Power Supply PP–674/TPS–1D. Also check for missing spare fuses.

(13) On the power supply, check each fuse for proper size according to the panel designation adjacent to the fust holder (fig. 56, TM 11–1167–10).

(14) On the left side of the servo amplifier assembly in the antenna base, check for open ventilation ports (fig. 33, TM 11–1167–10).

(15) Check the oil level in the antenna base gearcase as indicated on the oil level indicator (fig. 8, TM 11–1167–10) visible from the front of the equipment.

Caution: The oil level should be between the HIGH LIMIT and LOW LIMIT markings on the oil level indicator.

(16) Check for protective caps on receptacles which are not being used.

(17) On the power supply, check the seating of the plug on MAGNETRON AGING JACK J420.

(18) Check all meters and indicators for damage.

(19) Check for loose knobs.

b. Shelter Checks.

(1) Check Shelter S–68/TPS–1D (fig. 1, TM 11–1167–10) for undue strain on the tent and fly canvas, and for rips and abrasion. When a multiple stack installation is being used, check its shelter as explained above.

(2) Check all ropes for fraying. Take up any slack that may be present.

(3) Check zippers and snap fasteners for proper operation.

(4) Check security of all tent pins.

(5) At a remote antenna installation be sure that the shelter fly is installed over the antenna base unit.

c. Interior Checks.

(1) Check the unit chassis catches and catch releases (fig. 35, TM 11–1167–10) as follows.

(*a*) Unscrew the captive knurled and slotted screws, located around the panel edges of each unit, except the antenna base and antenna, until the panels are free.

(*b*) Pull each chassis outward, using panel hand-grabs, with the exception of Azimuth-Range Indicator IP–141/TPS–1D and the antenna base servo amplifier. Catches should stop each chassis when 16 inches out of its case.

Caution: There are no catches and catch releases on the indicator chassis and the antenna base servo amplifier chassis; therefore, be careful when pulling them outward for checks and adjustments. Watch for strain on unit cables when withdrawing a chassis.

(*c*) To release the catches so that the chassis may be pushed in or removed entirely from its case, hinge the catch release levers out at right angles to the side of the chassis.

Caution: If at any time it is necessary to pull the Signal Comparator CM–36/TPS–1D chassis out beyond the stopped position, there is danger of straining or breaking three cables which connect the signal comparator to its delay line. These cables must be disconnected on the signal comparator before it is pulled clear of its housing.

Note. To replace a chassis which has been removed entirely from its case or which has been pulled beyond the catches, place the catch release levers in the right angle position and then slide the unit back into its case.

(2) Check for proper mechanical operation of interlocks and the antenna base safety switch (par. 3*a* and *b*).

(3) Check for release of the local oscillator

assembly on its shock mounts (fig. 34, TM 11–1167–10).

(4) Check seating of all tubes and shields. Check tube types against reference designation markings adjacent to the tubes. Inside the signal comparator, check seating of test attenuator Z2350 which is mounted on fuse clips in rear of top side (fig. 30).

(5) Check cap connections to the following tubes:

(*a*) *Modulator.*
High-voltage rectifier V151 (fig. 27).
High-voltage rectifier V152 (fig. 27).
Charging diode V153 (fig. 27).
Charging diode V154 (fig. 27).
Shunt diode V155 (fig. 27).
Thyratron keyer V156 (fig. 27).

(*b*) *Indicator.*
Ppi scope V609 (fig. 23).
A scope V625 (fig. 26).
High-voltage rectifier V626 (fig. 26).

(*c*) *Receiver-transmitter.*
Keep-alive rectifier V501 (fig. 32).
Magnetron V502 (fig. 32).
Tr V504 (fig. 35).

(*d*) *Antenna base.*
Control rectifier V701 (fig. 29).
Control rectifier V702 (fig. 29).

(6) Check all coaxial cables for tightness of contacts and damage due to sharp bends.

(7) Compare all terminal strip markings with lead markings for correct connections. Check tightness of connections.

(8) Check components for freedom from dust, dirt, metal filings, etc.

(9) If a remote plan position indicator is being used, check for removal of jumper between R446 and R448 on resistor panel behind access door on lower right side of power supply (fig. 49, TM 11–1167–10).

(10) Check heater power link connections on E406 (fig. 51, TM 11–1167–10), located on the lower left front side of the power supply, as follows:

(*a*) *Utilization of heater power from the system power circuit.*
1. Check for link connection between W102 and 02.
2. Check for link connection between W103 and 03.

(*b*) *Utilization of heater power from a separate circuit via POWER IN HEATERS J404.*
1. Check for link connection between W102 and W02.
2. Check for link connection between W103 and W03.

(11) Inside the modulator, ascertain that the USEC DELAY switch (fig. 27) is in the 12.4 position unless specified otherwise in instructional material for identification friend or foe (iff) equipment, if used. If iff equipment is being used, also check for removal of jumper between R447 and R449 on resistor panel behind access door on lower right side of power supply (fig. 49, TM 11–1167–10).

(12) Check tropicalization seal for scratches and abrasions that break the surface of the varnish.

(13) Check each air filter. Remove any dirt accumulation. Filter removal procedures are given in paragraph 74*c*, TM 11–1167–10.

(14) Just prior to operating, check for closed units.

7. Standby Power Checks

Perform the following checks in the order given. Failure to take the necessary precautions or failure to perform the indicated checks may result in damage to the radar set. Correct any equipment malfunction before proceeding to the next check.

a. With the POWER switch on Azimuth-Range Indicator IP–141/TPS–1D (fig. 55, TM 11–1167–10) set in the OFF position, the ANTENNA ROTATE control on the indicator (fig. 55, TM 11–1167–10) set at 0 RPM on the ANTENNA SPEED dial and the TRIGGER switch on Radar Modulator MD–144/TPS–1D (fig. 54, TM 11–1167–10) set at EXTERNAL, apply power from the power unit to the equipment. When Gasoline Engine Generator Set PU–107/U

or Trailer Mounted Gasoline Engine Generator Set PU–253/U (PU–107/U mounted in a trailer) is used (fig. 18, TM 11–1167–10), follow operating instructions for 120-volt, single-phase, 10-kilowatt operation in TM 11–919.

Note. Heater power should be supplied continuously if temperature drops below 32° F.

b. On Power Supply PP–674/TPS–1D, check VOLTMETER M401 for a reading of 110 to 120 volts and check LINE FREQUENCY M403 meter for a reading of 384 to 416 cycles (fig. 56, TM 11–1167–10). If the indicated voltage or frequency is incorrect, check the power unit, following instructions in TM 11–919. Fixed Power Transformer Autotransformer TF–223/G (fig. 4) can be connected and adjusted to supply the system with 115 volts when the output of PU–107/U is close to or exceeds the maximum voltage requirement of the AN/TPS–1D (*g* below).

c. On the indicator, place the POWER switch in the ON position and check the power-on indicator I609 (fig. 13), located above the POWER switch, for illumination. Also, a spot of light should appear on both the A scope and the ppi scope.

Caution: Blower motors should be heard operating in the power supply, Radar Receiver-Transmitter RT–212/TPS–1D and Antenna Base AB–221/TPS–1D. Above a temperature of approximately 70° F., blowers should be operating in the other cased units and another blower should be operating in the antenna base. Investigate the failure of any blower to operate. The ventilating fan should operate when the ANT. BLOWER SWITCH on the power supply (fig. 56, TM 11–1167–10) is placed in the ON position.

d. The transmitter cannot be energized until the end of a warmup period. Check for a 5-minute warmup period. The warmup period is controlled by the setting of time-delay relay K401. A sharp click, emitted from the receiver-transmitter, can be heard when this period of time expires. If this period of time is not within 30 seconds of 5 minutes, adjust the time duration of the timing relay K401 (fig. 5) as follows:

Caution: This warmup time is applicable to

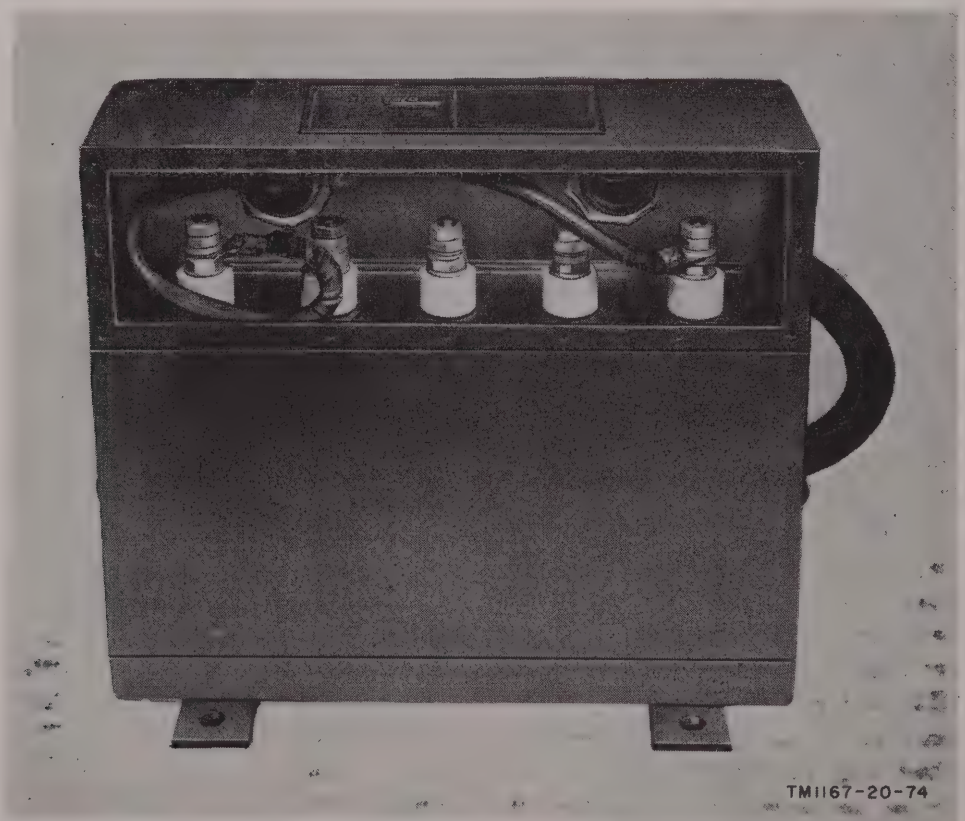


Figure 4. Fixed Power Transformer Autotransformer TF–223/G, access plate removed.

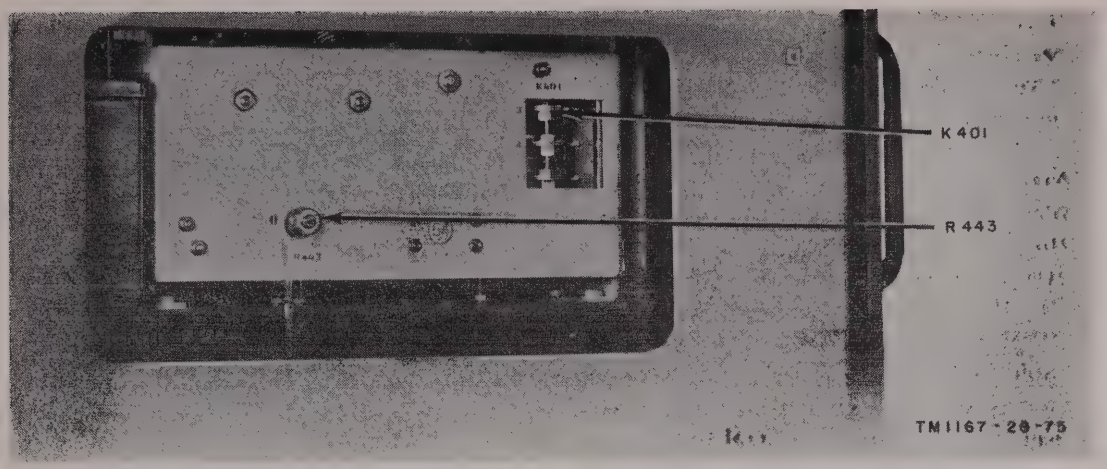


Figure 5. Power supply timing relay.

temperatures above 0° F. If a longer warmup period is not allowed at temperatures below 0° F., damage to the equipment may result when the transmitter is turned on. At the lowest operating temperature, —65° F., 30 minutes are required. Proportionately shorter warmup periods are permissible for temperatures up to 0° F.

(1) Pull the power supply chassis out as far as the drawer permits.

(2) Unlock R443, located on the upper left side of the power supply chassis (fig. 5).

(3) Adjust R443 to correct the timing. Clockwise rotation of R443 shortens the timing period while counterclockwise rotation lengthens the period.

(4) Lock R443.

e. On the power supply, during the warmup period, check the blown-fuse indicators. If an indicator is illuminated, indicating a blown fuse, replace the fuse with a spare of the correct indicated size. If the replaced fuse blows, troubleshooting is required.

Note. Spare fuses of various sizes will be found in the spare fuse holders on the power supply panel (fig. 56, TM 11–1167–10).

Caution: Be alert for any indications of damage to the equipment, such as excessive heat, unusual sounds, smoke, or odors.

f. During the warmup period, check the magnetron filament current as follows:

(1) On the receiver-transmitter, place the TEST SELECTOR switch in the MAG. FIL. position (fig. 57, TM 11–1167–10).

(2) On the test meter located above the TEST SELECTOR switch, check for a reading of 65 to 83 percent of full scale.

Note. When the transmitter is turned on (par. 8*d*), the reading should drop and be between 50 percent (red-line indication) and 65 percent of full scale.

g. At the expiration of the warmup period (*d* above) on the power supply, check VOLTMETER M401 for normal line voltage (*b* above). If the line voltage is close to or exceeds the maximum voltage requirement of the radar set when power is being provided by PU–107/U, it may be necessary to make use of Fixed Power Transformer Autotransformer TF–223/G. If so, proceed as follows:

(1) Remove the access plate on the fixed autotransformer to expose the terminals (fig. 4), which are clearly numbered, and one end of a 10-foot cable which is inserted through one of the bushings on the fixed autotransformer.

(2) With the radar set in operation, check the PU–107/U output voltage across output terminals marked PHASE–A and PHASE–B.

(3) Connect one of the lugs on the end of the cable, which is inserted through one of the bushings on the fixed autotransformer, to terminal 1 (COMMON). Connect the other lug to terminal 3 (120 VAC), terminal 4 (125

VAC) or terminal 5 (130 VAC), whichever is nearest in value to the output voltage of the PU–107/U ((2) above).

Note. Refer to the diagram on top of the fixed autotransformer.

(4) Stop the PU–107/U. Follow instructions in TM 11–919, and disconnect system power input cable W15 from PU–107/U output terminals marked PHASE–A and PHASE–B. Insert this cable through the remaining bushing on the fixed autotransformer, and connect it to terminal 1 (COMMON) and terminal 2 (115 VAC). Replace all terminal washers and nuts, and tighten them securely.

(5) Replace the access plate on the fixed autotransformer.

(6) Connect the other end of the 10-foot cable, which was attached to the fixed autotransformer ((3) above), to the PU–107/U output terminals marked PHASE–A and PHASE–B. Replace all terminal washers and nuts, and tighten them securely.

(7) Start the PU–107/U, following instructions in TM 11–919, and repeat the power checks.

8. Power Checks While Radiating

After the end of the warmup period (par. 7), proceed as follows:

a. Press the RADIATE ON button (fig. 55, TM 11–1167–10) while observing the MAGNETRON CURRENT meter (fig. 57, TM 11–1167–10) on the receiver-transmitter. The reading should be steady and in the range of 40 to 44 ma for normal line voltage (par. 7*b*). In addition, OPERATING HOURS M402 meter on the power supply (fig. 56, TM 11–1167–10) should operate when the equipment is radiating.

(1) If the magnetron current reading is incorrect, it may be necessary to proceed as follows:

Caution: Damage to the magnetron may result if the magnetron current exceeds 46 ma. If this occurs, trouble-shooting is required.

(*a*) *Magnetron aging.* High or unstable magnetron current may be due to gas in the magnetron. This condition usually can be corrected by aging the magnetron (*1–9* below). Excessive gas may accumulate in the magnetron if the equipment has been out of service for over a month. In addition, a new or previously used replacement tube must be aged. To age the magnetron, proceed as follows:

1. Turn the equipment off and, on the power supply, remove plug P420 from MAGNETRON AGING JACK J420 (fig. 56, TM 11–1167–10).

2. Connect Variable Power Transformer TF–171/USM (variac, fig. 6), part of Test Set AN/MPM–23 described in TM 11–1250, Test Set AN/MPM–23, to J420.

Note. Electrical Power Cable Assembly CX–3641/U, also part of Test Set AN/NPM–23, must be attached to the variac. Makeup of the cable assembly and connections to the variac are shown in figure 7.

3. Log the MAGNETRON TUNING dial reading (fig. 57, TM 11–1167–10) on the receiver-transmitter.

4. Rotate the MAGNETRON TUNING knob to the high-frequency end of the magnetron spectrum.

5. Turn on the equipment (par. 7*c*), press the RADIATE ON button after the end of the warmup period, and set the variac so that the magnetron plate current is approximately 20 ma.

6. Leave the equipment running under these conditions until stable magnetron operation is obtained.

Note. Stable magnetron operation is indicated by stable magnetron plate current and no arcing in the RF circuits.

7. After stable operation has been obtained at a plate current of 20 ma, slowly increase the plate current by means of the variac, stopping to permit the magnetron to stabilize whenever unstable operation is encountered.

8. After stable operation has been obtained at a plate current of 40–44 ma, slowly tune the magnetron to the low-frequency end of its spectrum, stopping to permit it to stabilize

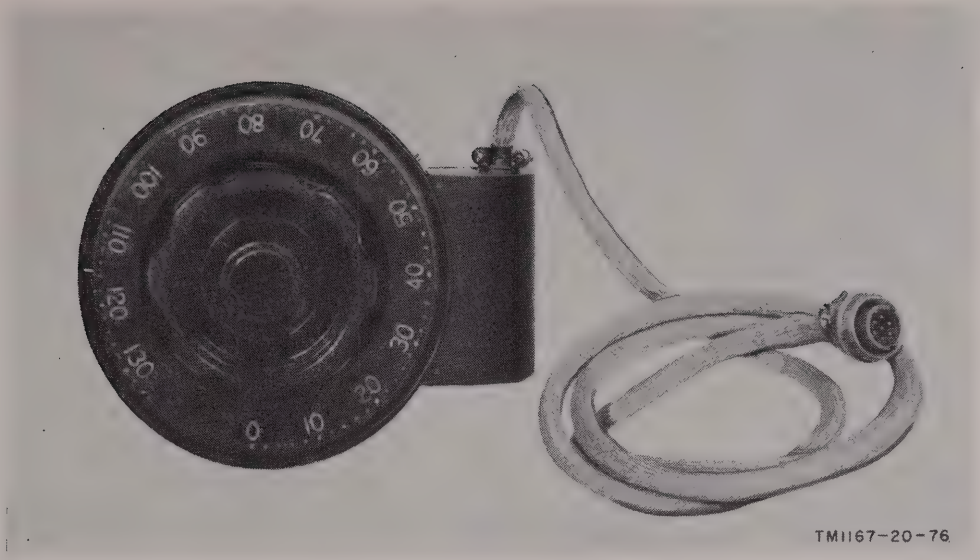


Figure 6. Variable Power Transformer TF–171/USM (variac).

whenever unstable operation is encountered.

9. Tune the magnetron to the original frequency and replace the variac plug at J420 with P420 (*1* above).

(*b*) *Carrier gate length control R1365 adjustment.* A fluctuating reading on the MAGNETRON CURRENT meter may be due to an incorrect setting of R1365, located inside Signal Comparator CM–36/TPS–1D (fig. 30). To adjust R1365, proceed as follows:

1. Turn R1365 fully clockwise. This causes a drop in the MAGNETRON CURRENT meter reading.

2. Increase the magnetron current by turning R1365 counterclockwise until the needle on the MAGNETRON CURRENT meter jumps to a reading in the range of 40–44ma. At this point, R1365 can be turned several degrees in either direction without changing the magnetron current.

3. Center R1365 between the extreme positions which provide the same value of magnetron current.

Note. Final setting of R1365 will be accomplished during a later alinement procedure (par. 14*f*).

(*c*) *Modulator high-voltage adjustment.* The taps on the primary winding of high-voltage transformer T151 (fig. 27) permit adjustment of the high-voltage dc supply in the modulator. It is expected that the tap connections will not have to be changed unless line voltage conditions demand it, but the magnetron current reading may indicate a need for adjustment. For a 115-volt, 400-cycle input, the primary taps affect the secondary voltage of T151 as follows:

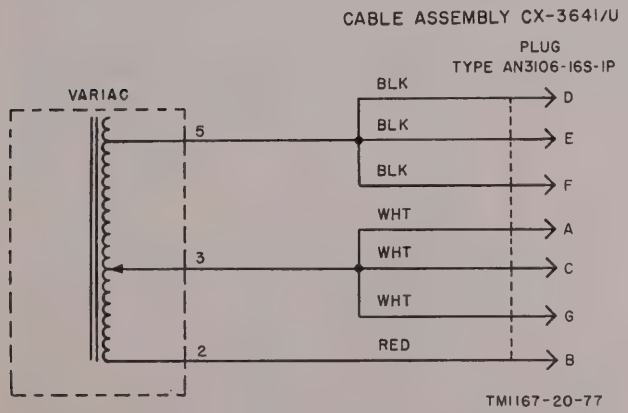


Figure 7. Variac connections for aging magnetron.

Primary taps	Total secondary volts
1–4	9,100
2–4	9,600
1–3	9,900
2–3	10,500

1. Adjust the line voltage (par. 7*b*) for readings of 115 volts on VOLTMETER M401 and 400 cycles on LINE FREQUENCY M403 meter, located on the power supply, after at least a 15-minute warmup period. If line supply adjustment is not possible, adjust the T151 taps at a time when the line voltage and line frequency are at average values.
2. On the receiver-transmitter, note the magnetron current reading on the MAGNETRON CURRENT meter and determine whether an increase or decrease in voltage is required.
3. Turn the equipment off and adjust the primary taps as indicated above.

Warning: Observe high-voltage warnings. In the modulator, ground pin 2 of either V151 or V152 while making the adjustment. Remove the ground and close the unit when checking the adjustment. Avoid direct contact with ground, when possible.

(2) If the transmitter shuts down, or if it cannot be kept on the air for more than a few seconds at a time, it may be necessary to perform the following:

(*a*) *Resetting overtemperature switch S501.* Transmitter overtemperature protection is provided by a thermo-operated switch S501 (fig. 32) mounted adjacent to the magnetron oscillator tube. If the temperature rises above 185° F., the switch will operate and cause the transmitter to shut down. However, operation of a transmitter overload protective relay will also cause the transmitter to shut down ((*b*) below). Proceed as follows:

Warning: High-voltage pulses are present above the receiver-transmitter chassis when transmitting. When transmitting, keep clear of all circuits on the receiver transmitter other than those accessible through the bottom hinged access door.

1. Check for indication of a blown fuse. If none is present, push the RADIATE ON button. If the overtemperature switch has operated, the transmitter cannot be turned on, as evidenced by no magnetron current.
2. Investigate the overtemperature condition. If a dirty air filter is suspected as the cause of the trouble, clean the filter (par. 74*c*, TM 11–1167–10).
3. After the condition is corrected, reset the overtemperature switch by pressing the reset button.

(*b*) *Protective relay balance adjustment R168.*

1. Push the RADIATE ON button. If a sustained overload condition is responsibile for the shutdown, it undoubtedly will be impossible to keep the transmitter on for more than a few seconds at a time. Sustained overloads usually result from a defective magnetron or modulator tube, continuing arc-overs, defective components, etc; therefore, trouble-shooting by a higher echelon may be required.
2. If it is suspected that relay balance R168 (fig. 8) for protective relay K151 in the modulator is out of adjustment (it may have been inadvertently turned during the installation), proceed as follows:

Caution: Relay K151 provides protection for transmitter and modulator circuits. It is designed to operate when overloads exist in these circuits. Relay balance R168 for this protective relay, does not normally require readjustment. Do not simply readjust R168 to the setting where the transmitter will stay on the air. Damage to the equipment may result. Emergency operation may be an exception to this rule provided that watch is kept for excessive arcing and abnormal magnetron current.

(a) Make sure that magnetron current is normal (*a* above).

(b) While transmitting, check the

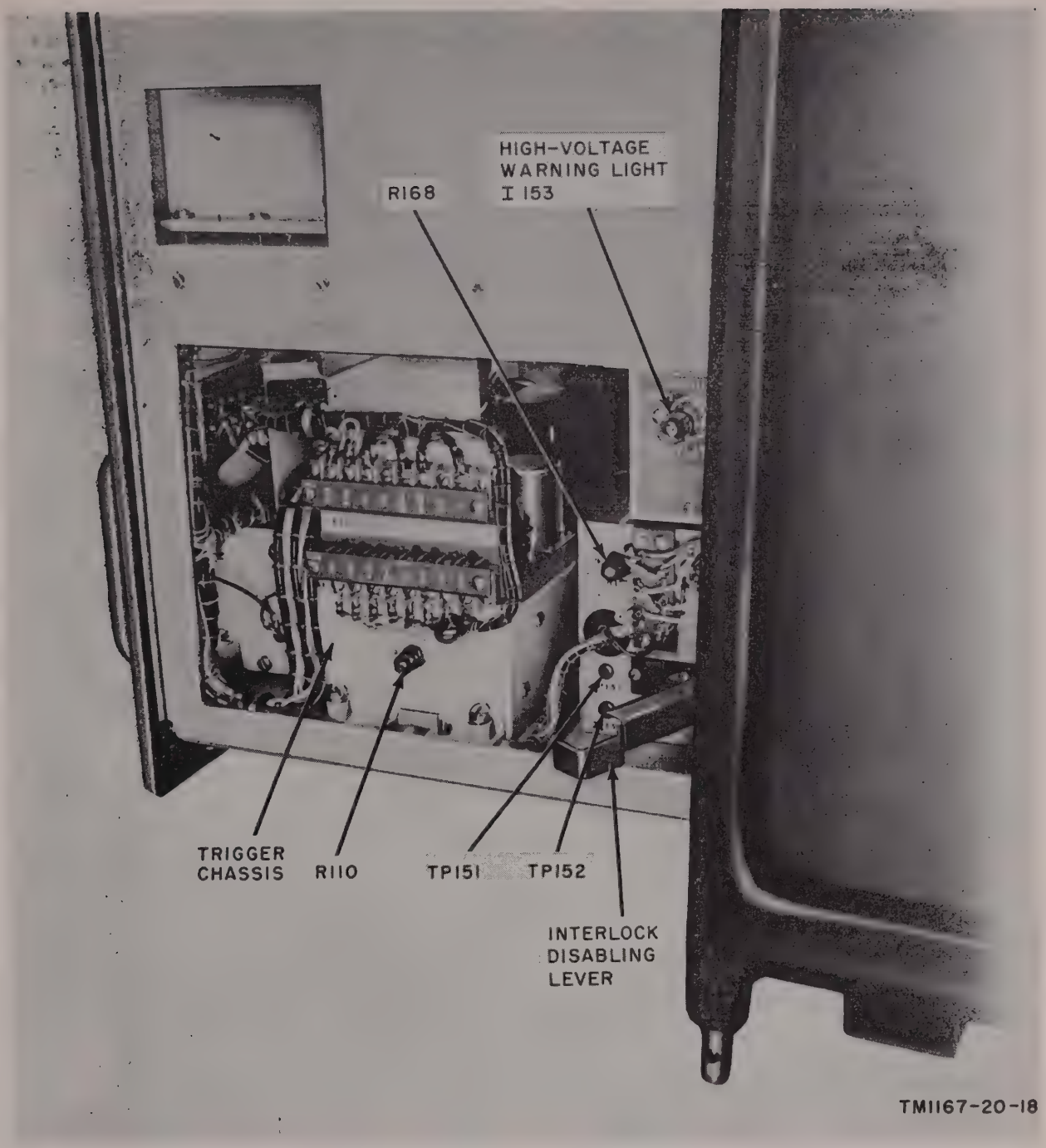


Figure 8. Modulator details, right side.

voltages (dc) between terminals 1 and 5 and between terminals 6 and 7 on the K151 terminal board adjacent to R168.

(c) Unlock and adjust R168 so that these voltages are equal. Voltage readings should be between 4 and 5 volts.

(d) Lock R168.

(*c*) *Magnetron aging.* Follow the procedure explained in *a*(1) (*a*) above.

(3) If the transmitter shuts down occasionally, the shutdown may be caused

by a temporary overload, such as an overload caused by a momentary arc-over in the RF system, or by a slight gas condition in the magnetron tube. Transmitter shutdown due to the operation of the overload protective relay can be tolerated provided that the shutdown does not occur more than once or twice an hour. Frequency *skipping*, a condition in which the magnetron oscillates on either of two frequencies at random, may cause the overload protective relay to operate. If so, the condition may be corrected by turning the MAGNETRON TUNING control (fig. 57, TM 11–1167–10) for a frequency shift of from 10 to mc. Transmitter frequency may be obtained from Test Set TS–172A/UP (echo box), used during receiver alinement (par. 13).

Note. If there is the possibility of interference with other radars operating in the same frequency range, the transmitter frequency range, the transmitter frequency should be set at least 150 mc away from other radar operating frequencies. The transmitter frequency may be approximated by reading the MAGNETRON TUNING control dial and interpolating. The number on the top dial will change by one for each revolution of the large dial. Readings can be obtained from 0 to 1000, which represents the frequency range of the magnetron (1220–1350 mc).

b. Check for magnetron filament meter reading (par. 7*f*) of 50 percent (red-line indication) to 65 percent of full scale.

c. Check for antenna rotation at various settings of the ANTENNA ROTATE control (fig. 55, TM 11–1167–10) on the indicator while transmitting. Speed of rotation will be adjusted during a later alinement procedure. If the servo amplifier in the antenna base is overloaded, the antenna speed will drop to approximately 1 rpm or less; and will not increase no matter where the ANTENNA ROTATE control is placed. If these symptoms of an overload are present, turn the ANTENNA ROTATE control back to a setting of 0 RPM on the ANTENNA SPEED dial. Wait 4 to 5 seconds, then advance the ANTENNA rotate control. If the antenna does not rotate normally, troubleshooting by a higher echelon may be required.

Note. The antenna cannot be rotated until the end of the 5-minute warmup period. Also, the safety switch on the antenna base (fig. 8, TM 11–1167–10) must be in the ON position. Ppi sweep rotation is synchronized with the antenna rotation. If the sweep appears to jump at one point in rotation or if it does not follow the antenna rotation smoothly, need for synchro alinement is indicated. This will be performed after power supply adjustments.

9. Power Supply Adjustments

Note. Always make voltage adjustments in Power Supply PP–674/TPS–1D when the system is in full operation.

a. +150-volt Supply Adjustment.

(1) Measure the voltage between terminal 01 (ground) on terminal board E404 and terminal 1A on terminal board E401 (fig. 31).

(2) Unlock and adjust R416 (fig. 31) for a reading of +150 volts ((1) above).

(3) Lock R416.

b. +300-volt Supply Adjustment.

(1) Measure the voltage between terminal 01 on E404 and terminal 4A on E401.

(2) Unlock and adjust R433 (fig. 31) for a reading of +300 volts ((1) above).

(3) Lock R433.

10. Synchro Alinement

A 24-speed synchro system is used to synchronize the rotation of the ppi sweep with the antenna rotation. In addition, a 1-speed synchro transmitter is used to transmit azimuth information for remote ppi use. If the ppi sweep does not follow the antenna rotation smoothly, need for alinement of the 24-speed synchro system is indicated. The 1-speed synchro transmitter is alined so that azimuth indication on the remote plan position indicator is the same as the azimuth indication on Azimuth-Range Indicator IP–141/TPS–1D, after orientation of ppi images for true readings in relation to the azimuth scale surrounding the ppi tube (par. 15) has been completed. Do not aline the 24-speed synchros unless there are definite indications of synchro misalinement. The synchro alinement should be performed under the supervision of higher echelon maintenance personnel.

a. Alinement of 24-Speed Synchros.

(1) *Synchro transmitter B752.*

(*a*) Remove the antenna drive unit assembly cover on Antenna Base AB–221/TPS–1D (fig. 9).

(*b*) After the end of the 5-minute warmup period, rotate the antenna slowly and stop rotation when the point of 1-speed S756 cam is resting on the roller of microswitch S756 (fig. 9).

(*c*) Turn the equipment off and disconnect the S_1, S_2, and S_3 leads from B752 (fig. 9). Also, using a jumper, connect R_1 to S_2 on B752.

(*d*) Turn the equipment on. It is not necessary to wait until the end of the 5-minute warmup period.

(*e*) Loosen the four B752 clamp screws (fig. 9), and rotate the body of B752 until the measured ac voltage between S_1 and S_3 on B752 is 0 volts.

Caution: The highest voltage to be encountered during this alinement procedure is approximately 193 volts ac. Choose the multimeter scale accordingly.

(*f*) Measure the voltage between S_1 and R_2 on B752. If the voltage is approximately 37 volts ac, B752 is at or near its zero position. If the voltage is approximately 193 volts ac, B752 is 180° out of position. If the latter is the case, rotate the body of B752 180° and rezero ((*e*) above).

(*g*) Remove the jumper from R_1 and S_2 on B752.

(*h*) Connect the multimeter between S_1 and S_3 on V752 again, and with the meter on its low ac voltage scale, carefully rotate the body of B752 until a minimum voltage is obtained. Carefully secure the body clamp of B752.

(*i*) Turn the equipment off, and connect the S_1, S_2, and S_3 leads.

(2) *Synchro receiver B602.*

(*a*) Pull the indicator chassis out until the cover of the deflection coil (L601) assembly is accessible. Remove the cover of this assembly to expose the 1-speed S612 cam and microswitch S612 (fig. 10).

(*b*) Turn the equipment on. After the end of the 5-minute warmup period, rotate the antenna slowly and stop rotation when the center of the 1-speed S612 cam is resting on the roller of microswitch S612 (fig. 10).

(*c*) Turn the equipment off, and on the antenna drive unit assembly (fig. 9) in the antenna base, connect a jumper from terminal 8A8 to chassis ground at terminal board E753 (fig. 9).

Note. This connection applies a zeroing voltage to synchro receiver B602 (fig. 24) after the end of the 5-minute warmup period.

(*d*) Turn the equipment on. After the end of the 5-minute warmup period, B602 will be locked in its electrical zero position.

(*e*) Inspect the position of the 1-speed S612 cam in relation to the roller of microswitch S612. If the center of the cam is resting on the roller of S612, no adjustment of the body of B602 is necessary. If the center of the cam is not resting on the roller of S612, loosen the four B602 body clamp screws and carefully rotate the body of B602 until the center of the cam is resting on the roller of S612. Carefully secure the body clamp of B602.

(*f*) Turn the equipment off, remove the jumper from terminal 8A8 and chassis ground at terminal board E753, and replace the deflection coil (L601) assembly cover.

(*g*) If alinement of 1-speed synchro transmitter B753 (*b* below) is not necessary, replace the antenna drive unit assembly cover.

(*h*) Turn the equipment on.

b. Alinement of 1-Speed Synchro Transmitter B753. For remote plan position indicator operation, B753 (fig. 9) is alined after the ppi images have been oriented for true readings in relation to the azimuth scale surrounding the ppi tube (par. 15). Also, it is assumed that the remote plan position indicator sweep rotates in the same direction and at the same speed as the AN/TPS–1D antenna.

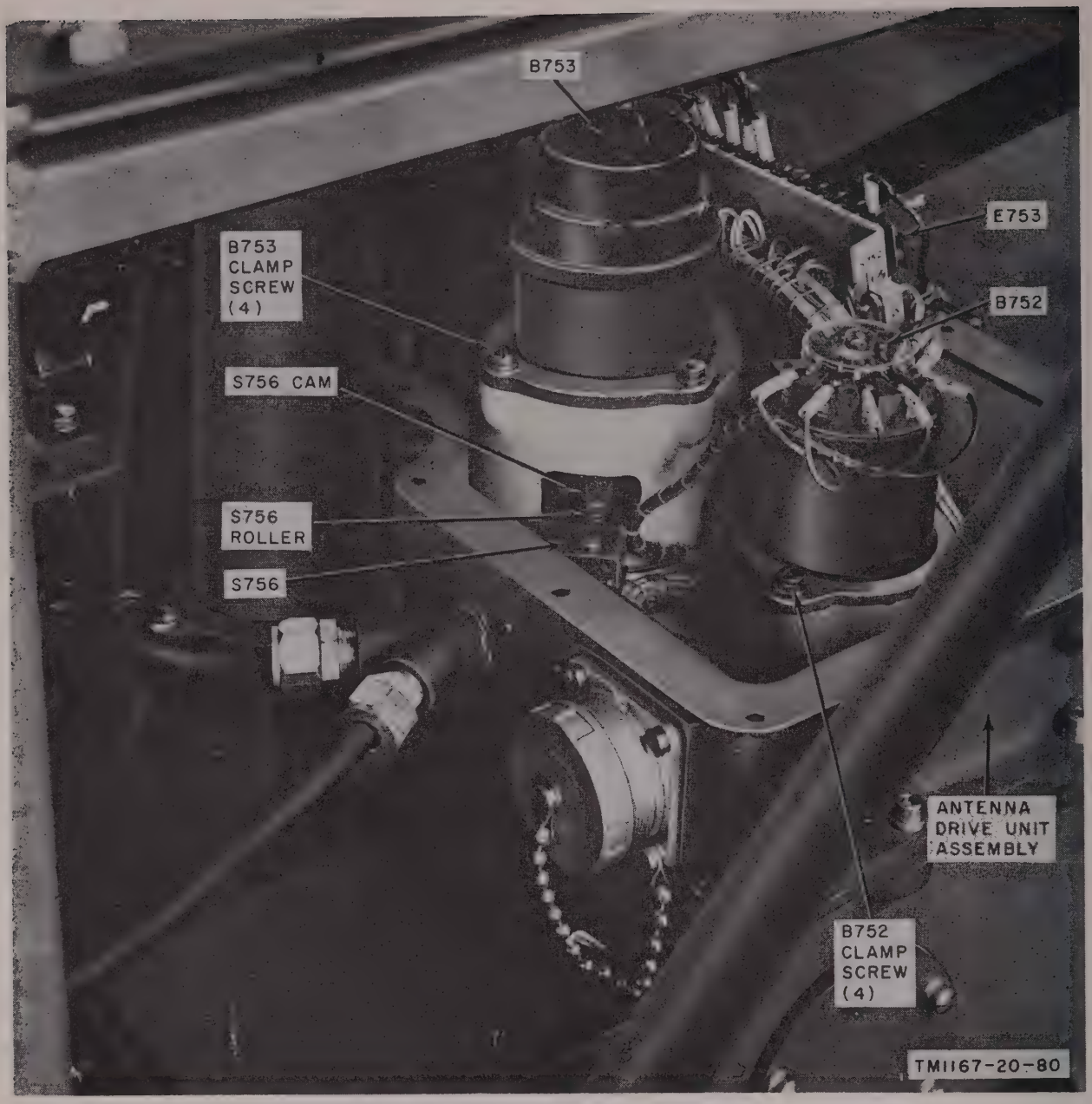


Figure 9. Antenna drive unit assembly component locations.

(1) After the end of the 5-minute warmup period, position the antenna so that the AN/TPS–1D indicator ppi sweep is exactly at the 0° position on the azimuth scale surrounding the ppi tube.

(2) After removal of the antenna drive unit assembly cover (*a*(1) (*a*) above), loosen the four B753 body clamp screws (fig. 9) and carefully rotate the body of B753 until the RPPI sweep is at the 0° position.

(3) Carefully secure the body clamp of B753 and replace the antenna drive unit assembly cover.

11. Servo Amplifier Alinement

Improper adjustment of the servo amplifier (fig. 8, TM 11–1167–10) controls could cause hunting, a tendency to stall with wind loading, incorrect rotation speeds, creeping when the

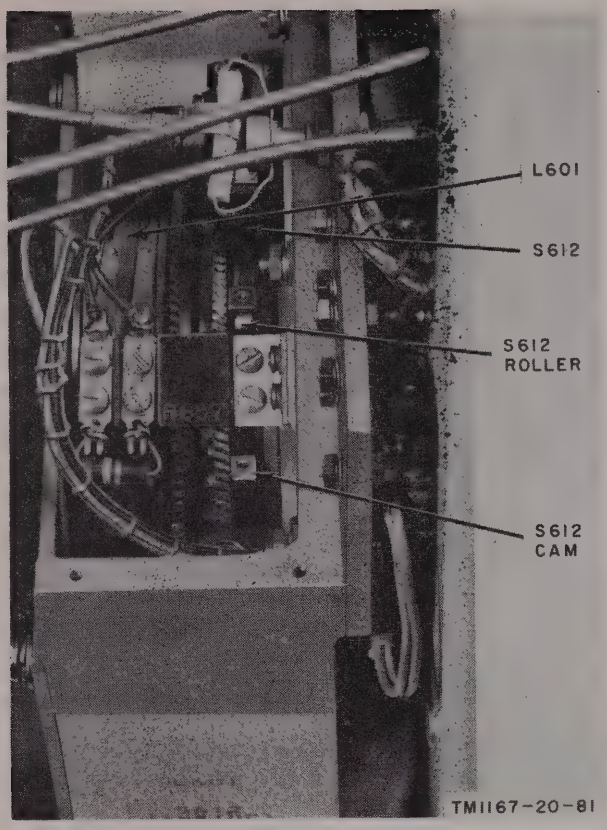


Figure 10. Deflection coil (L601) assembly.

ANTENNA ROTATE control (fig. 55, TM 11–1167–10) is set for O RPM, etc. If it is suspected that servo amplifier controls were inadvertently turned or loosened during the installation, the following adjustments should be made under the supervision of higher echelon maintenance personnel.

Note. To make servo amplifier adjustments, it is necessary to disable interlock S701 (par. 3*a*(6)).

Caution: Mark the position of each control before adjustment so that the control can be returned to its original setting, if necessary. When making adjustments, keep close watch of the thyratron plates, V701 and V702 (fig. 29), which must not be heated to the point where they are red for more than 1 minute. The theory of the servo amplifier operation should be understood before making an adjustment.

a. Current-Voltage Feed-Back Adjustment.

Caution: Do not allow the antenna to hunt violently during this procedure. If the antenna oscillates excessively during the adjustment, remove power by placing the antenna base safety switch (fig. 8, TM 11–1167–10) in the OFF position, and start over again.

Note. Allow a warmup period of at least 15 minutes before making adjustments.

(1) With the ANTENNA ROTATE control on Azimuth-Range Indicator IP–141/TPS–ID set at 0 RPM on the ANTENNA SPEED dial (fig. 55, TM 11–1167–10), unlock ANTENNA SPEED control R2619 (fig. 13) and set it to its midposition. Lock R2619.

(2) Turn the ANTENNA ROTATE control to a cw or counterclockwise (ccw) setting of 14 RPM on the ANTENNA SPEED dial.

(3) Unlock and set R710 completely ccw, and unlock and adjust R707 for 14 RPM of the antenna (fig. 11). Lock R707.

Note. To determine the antenna speed, observe the second hand on a watch.

(4) Turn the ANTENNA ROTATE control to a setting of approximately 6 RPM on the ANTENNA SPEED dial.

(5) With multimeter connected to TP702 (+) inside the servo amplifier (fig. 29) and ground (—), and with a dc voltage measurement setup on a full-scale range of 50 volts, slowly turn R710 cw until the system shows signs of hunting, as indicated by oscillations of the multimeter needle. Turn R710 ccw ¼ turn. The oscillations should stop. Lock R710.

Note. The glow of thyratrons V701 and V702 will flicker at a slow rate when these oscillations occur.

(6) Set the ANTENNA ROTATE control for 14 RPM on the ANTENNA SPEED dial, and compare the antenna speed with the ANTENNA SPEED dial indication. If slightly incorrect, correct the antenna speed by adjusting ANTENNA SPEED control R2619 as explained in paragraph 12*c*.

b. Thyratron Bias Adjustment.

(1) With the ANTENNA ROTATE control on the indicator set at 0 RPM, slowly turn this control cw until relay K702 (fig. 29), located just behind the servo amplifier panel on top of the

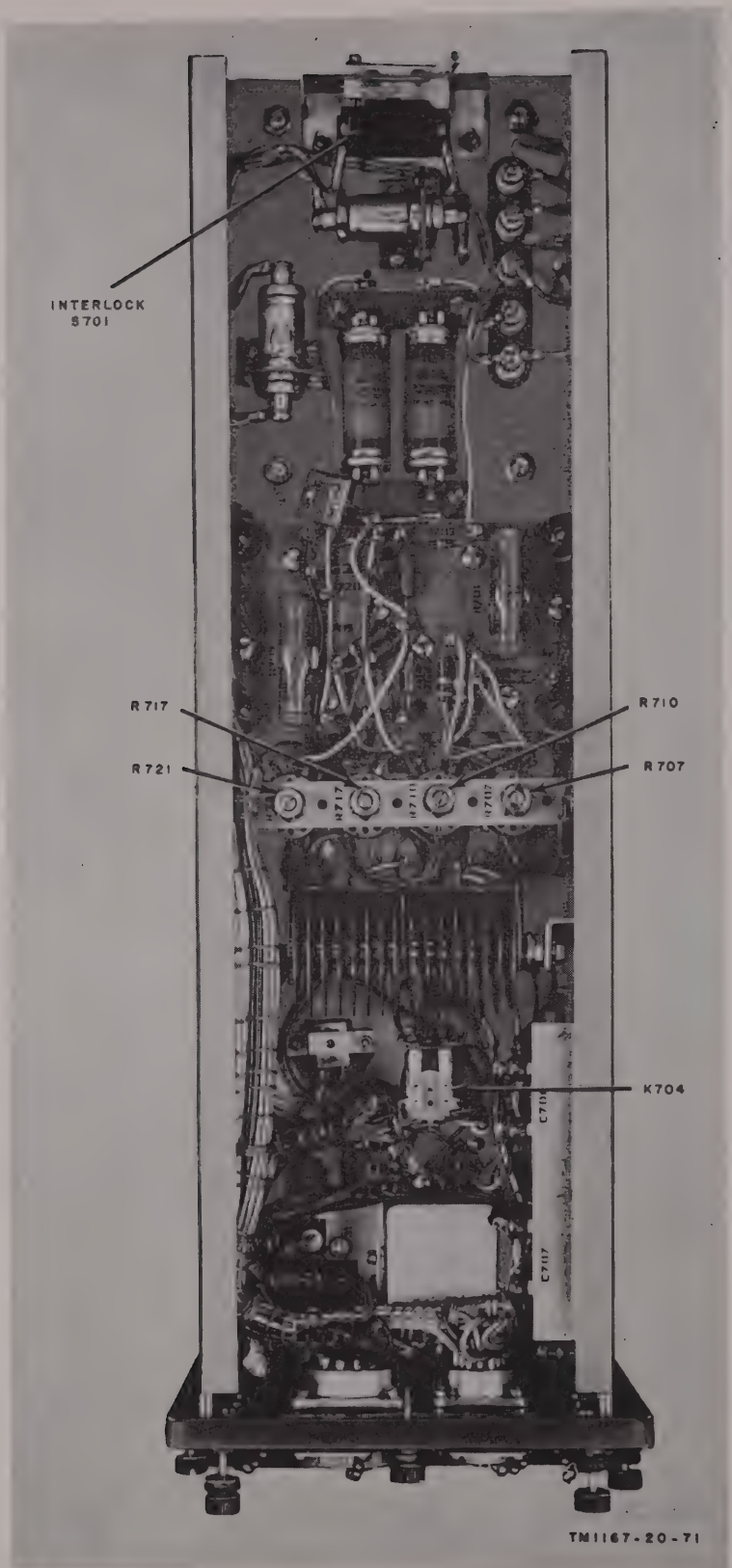


Figure 11. Servo amplifier details, bottom side.

chassis, just deenergizes. Only a slight turn is required.

Note. To keep the ANTENNA ROTATE control in this position for the following procedures, it may be necessary to adjust a detent (fig. 12) on the ANTENNA ROTATE control mechanism. To adjust the detent, unlock the detent adjustment (fig. 12) and set it to a position which allows the ANTENNA ROTATE control to remain in the proper position, as explained above. When the thyratron bias adjustment is completed, return the detent adjustment to its original position and lock.

(2) Unlock and turn R721 (fig. 11) fully ccw.

(3) Turn R721 cw until thyratrons V701 and V702 just fire.

Note. A glow will be seen in the thyratrons when they fire.

(4) Turn R721 ccw $\frac{1}{8}$ turn. The glow of V701 and V702 should just extinguish.

(5) Lock R721 and return the ANTENNA ROTATE control to 0 RPM.

c. Overload Adjustment.

Caution: During the following adjustment, do not allow the thyratrons to become red for more than a minute.

(1) Lash the antenna to the top of the tower with rope to prevent it from rotating. Procedure for gaining access to the antenna is explained in paragraph 6*a*(8).

Caution: Do not attach rope to RF coaxial lines.

(2) Connect multimeter to TP702 (+) and ground (—). Use a dc voltage measurement setup on a full scale range of 250 volts.

(3) After the equipment is energized, allow a 10- to 15-minute warmup period.

(4) Unlock and set R717 (fig. 11) fully cw. Slowly turn the ANTENNA ROTATE control on the indicator until the multimeter reads 80 volts.

(5) After a 5- to 10-second wait, slowly turn R717 ccw in small increments while observing the multimeter. Watch for a sudden drop in the multimeter reading. After this occurs, return the ANTENNA ROTATE control to 0 RPM.

(6) After a 4- to 5-second wait, slowly advance the ANTENNA ROTATE control in the same direction as before until the multimeter reads 70 volts. After a 5- to 10-second wait, slowly advance the ANTENNA ROTATE

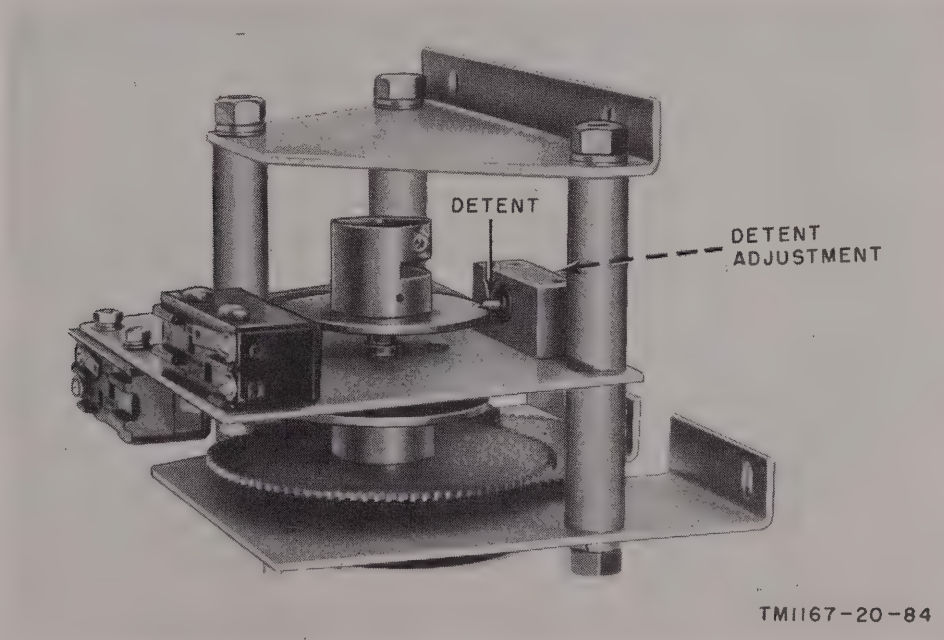


Figure 12. Antenna rotate control mechanism, rear.

control in the same direction in increments which produce a 2-volt change in the multimeter reading.

(7) Watch for a sudden drop in the multimeter reading. If the adjustment of R717 is correct, the sudden drop in the multimeter reading will occur within ±2 volts of 80 volts. Readjust R717 if necessary, lock R717, and return the equipment to its normal operating condition.

12. Indicator Alinement

Note. All locked controls should be relocked after adjustment.

Caution: There is no chassis catch on this unit (par. 6*c*(1)).

a. A-Scope Adjustments.

(1) On Azimuth-Range Indicator IP–141/TPS–1D, place the A RANGE SELECTOR switch (fig. 55, TM 11–1167–10) in the 160 mile position.

(2) While transmitting, turn the A-scope VIDEO GAIN control (fig. 55, TM 11–1167–10) fully ccw, and adjust the A-scope INTENSITY control (fig. 55, TM 11–1167–10) for the desired illumination.

(3) Adjust the A-scope FOCUS and ASTIG controls (fig. 55, TM 11–1167–10) for a fine, clear sweep.

(4) Adjust the A-scope HORIZ CENTER and VERT CENTER controls (fig. 55, TM 11–1167–10) to position the trace across the center of the A scope.

(5) Hold the RANGE MARKS MILES switch in the TEST position (fig. 55, TM 11–1167–10) and count the number of small (5-mile) markers between the large (25-mile) markers. There should be four small markers between the large markers. If incorrect, adjust BO. ADJ. R1618 (fig. 25) for the correct number of markers. Markers should be steady.

Note. RANGE MARKS MILES is marked on a reversible nameplate. Equipments are shipped with this nameplate reading RANGE MARKS MILES, which is applicable for services using mile measurements. The reverse side of the nameplate reads RANGE MARKS YARDS and is intended for the use of services using yard measurements. When shipped, the equipments are preset for 10,000-yard markers (5-mile markers) and 50,000-yard markers (25-mile markers).

(6) Adjust the A GATE control R1669 (fig. 24) for a sweep which represents slightly more than 160 miles. Use the range markers for calibration.

Note. It may be necessary to turn the A SCOPE SWEEP LENGTH control (fig. 55, TM 11–1167–10) to adjust the physical length of the sweep.

(7) Hold the RANGE MARKS MILES switch in the TEST position and adjust the MARKER GATE control (fig. 55, TM 11–1167–10) for a gate width just sufficient to include the 160-mile marker.

(8) Adjust the A GATE control for a sweep which represents 160 miles.

(9) Adjust the A SCOPE SWEEP LENGTH control for a sweep which almost touches the circumference of the tube face at both extremities.

(10) Check all settings of the A RANGE SELECTOR switch for the proper number of range markers on the A scope and a sweep which does not go off the tube face.

Note. With the RANGE MARKS MILES switch in the ON position, there are 5 miles between markers when the A RANGE SELECTOR is in the 20-mile, 40-mile or EXT position; there are 25 miles between markers when the A RANGE SELECTOR switch is in the 80-mile or 160-mile position.

b. Ppi-Scope Adjustments.

(1) Place the PPI RANGE SELECTOR switch (fig. 55, TM 11–1167–10) in the 160-mile position.

(2) Turn the ppi scope VIDEO GAIN control (fig. 55, TM 11–1167–10) fully ccw, and adjust the ppi scope INTENSITY control (fig. 55, TM 11–1167–10) and the COARSE INTENSITY control R660 (fig. 25) for a barely visible sweep.

(3) Adjust the ppi-scope FOCUS control (fig. 55, TM 11–1167–10) for a fine, clear sweep.

(4) Adjust the PPI CENTERING controls

(fig. 55, TM 11–1167–10). Accurate centering can be accomplished when use is made of the cursor line on the cursor assembly (fig. 59, TM 11–1167–10). Zero-range end of the ppi sweep should be located in the center of the screen, as viewed with the sweep rotating.

(5) Adjust the 5–10 MILE MARKER INT., the 25–10 MILE MARKER INT., and the STROBE INT. controls (fig. 55, TM 11–1167–10) for the desired intensity.

(6) Adjust the PPI GATE control R626 (fig. 24, TM 11–1167–10) for a sweep which represents 160 miles.

(7) Adjust the PPI SWEEP LENGTH control (fig. 55, TM 11–1167–10) for a sweep which barely touches the circumference of the tube face at all points in azimuth.

(8) Check all settings of the PPI RANGE SELECTOR switch for the proper range representation, as indicated by the range markers, and a sweep which does not go off the tube face.

(9) Turn the RANGE STROBE control (fig. 55, TM 11–1167–10) fully cw and adjust the STROBE LIM control (fig. 55, TM 11–1167–10) for coincidence of the range strobe (movable marker) and the 150-mile marker.

c. Antenna Speed Adjustment.

(1) Turn the ANTENNA ROTATE control to a cw or ccw setting of 14 RPM on the ANTENNA SPEED dial (fig. 55, TM 11–1167–10). While watching the second hand on a watch, compare the number of revolutions per minute of the antenna with the setting on the ANTENNA SPEED dial. If incorrect (not with $\pm\frac{1}{2}$ rpm of the indicated speed), make adjustment as follows:

(*a*) Unlock ANTENNA SPEED control R2619 (fig. 13).

(*b*) Adjust R2619 for 14 rpm of the antenna, as obtained by counting the rpm.

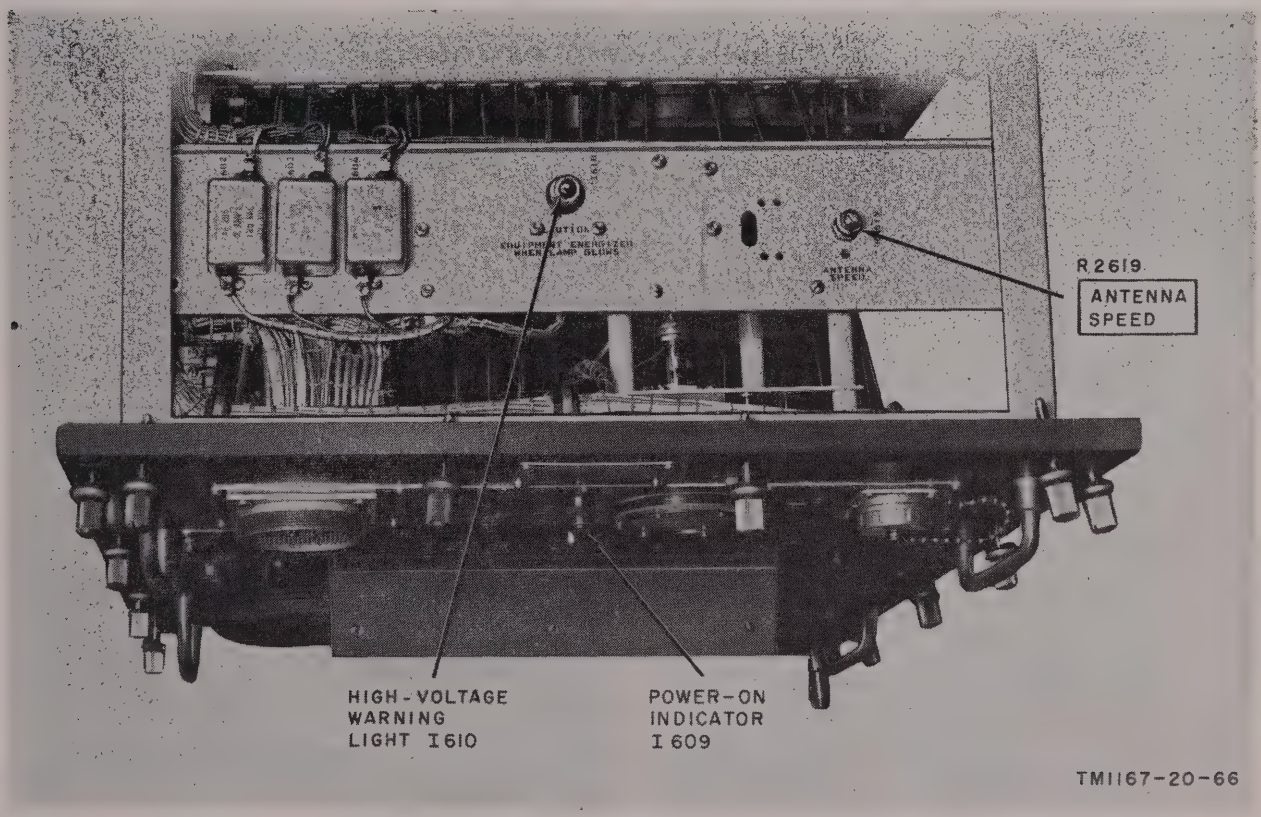


Figure 13. Indicator details, front and top side.

(2) Check the operation at 14 rpm in the reverse direction and lock R2619. Stop antenna rotation.

13. Receiver Alinement, Normal Operation

Note. All locked controls should be relocked after adjustment.

a. Preparatory to aligning the radar receiver, position the controls as indicated in the chart below.

Control	Unit	Position
ANTI JAM	Indicator	OFF
OPERATION	Indicator	NORM
VIDEO GAIN (both controls).	Indicator	Midposition
RECEIVER GAIN	Indicator	Midposition
RANGE SELECTOR (both controls).	Indicator	20
TRIGGER	Modulator	EXTERNAL *
OPERATION SELECTOR.	Signal comparator.	REMOTE
TEST SELECTOR	Signal comparator.	OFF

*The TRIGGER Switch (fig. 54, TM 11-1167-10) is normally placed in the EXTERNAL position for both normal and mti operation. It is placed in the INTERNAL position only in an emergency in the event of the failure of external triggers, as an aid to troubleshooting, and as an antijam measure so that the pulse-repetition frequency may be changed by turning the REP. RATE CONTROL (fig. 54, TM 11-1167-10).

b. Connect cable provided with Test Set TS-172A/UP (echo box) from the INPUT jack on the echo box (fig. 15, TM 11-1167-10) to RF TEST jack J501 (fig. 57, TM 11-1167-10) on the receiver-transmitter.

Note. If it is desired to change the operating frequency of the radar set, adjust the MAGNETRON TUNING control (fig. 57, TM 11-1167-10) before proceeding.

c. Allow a 15-minute warmup period after energizing the transmitter before proceeding further (par. 7*d*).

Note. A mirror is provided to facilitate the viewing of scope patterns while adjusting the radar system. This mirror is particularly useful when aligning the receiver. When making adjustments, clamp the mirror around the bezel of the A scope (fig. 59, TM 11-1167-10). Replace it in its protective covering and store in spare parts case when not in use. Viewing hoods for the scopes are provided in the spare parts case.

d. If saturated signals are present, set the A-scope VIDEO GAIN control (fig. 55, TM 11-1167-10) for a signal level of approximately 1 inch. Control setting should be at a point where the signals are just at maximum amplitude.

e. With the echo box TUNE-READ RINGTIME lever in the TUNE position, adjust the echo box tuning knob for maximum meter deflection. Be careful not to adjust to a secondary peak. Place the TUNE-READ RINGTIME lever in the READ RINGTIME position.

f. Adjust the RECEIVER GAIN control (fig. 55, TM 11-1167-10) for a grass (noise) level of one-fourth of the saturation level on the A scope.

Note. This corresponds to a grass level of approximately ¼ inch.

g. Inside Signal Comparator CM-36/TPS-1D, adjust C305 (fig. 30) for maximum grass on the A scope.

h. Readjust the RECEIVER GAIN control as explained in *f* above.

Note. The best estimate of the grass level is obtained when the A RANGE SELECTOR switch (fig. 55, TM 11-1167-10) is placed in the 160-mile position.

i. On Radar Receiver-Transmitter RT-212/TPS-1D, place the TEST SELECTOR switch (fig. 57, TM 11-1167-10) in the SIG position; check for an indication of crystal current on the test meter located above the TEST SELECTOR switch. If there is no indication, adjust the signal mixer-local oscillator coupling by turning the signal mixer coupling adjustment (fig. 34) for a red-line reading on the meter, after loosening the knurled ring-nut which locks the coupling adjustment. If this adjustment fails to produce an indication of crystal current, check for a missing or improperly seated signal mixer crystal (CR503), which is inserted in a T-shaped crystal holder (E527) adjacent to the signal mixer coupling adjustment (fig. 34). See paragraph 38.

Note. To gain access to the bottom of the receiver-transmitter, open the hinged access door beneath the unit after pulling the unit out of its case as far as the catches allow.

j. Hold the L.O. MOTOR switch (fig. 55, TM 11-1167-10) in the INC position for approximately 30 seconds.

k. Decrease the local oscillator frequency in small steps by flipping the L.O. MOTOR switch to DEC and allowing it to return to OFF each time.

(1) Decrease the local oscillator frequency until ringtime appears on the A scope (fig. 14).

Note. The echo box TUNE-READ RINGTIME lever position (*e* above) when adjusting in the READ RINGTIME position (*e* above) when adjusting the local oscillator frequency for maximum ringtime. It must be placed in the TUNE position if it is necessary to readjust the tuning knob for maximum meter deflection on the echo box.

Caution: While performing this procedure, observe the reading on the test meter located above the TEST SELECTOR switch on the receiver-transmitter. Do not allow crystal current to go substantially above the red line indication.

(2) Adjust the local oscillator frequency for maximum ringtime.

Note. If no echo box is available, it is possible to tune for maximum target amplitudes. If a cobweb or indistinct appearance of signals are noted, the magnetron frequency may not be stable. It may be necessary to readjust the magnetron frequency (par. 8*a*(3)). If so, repeat the normal receiver alinement.

l. Adjust the tuning knobs of tr tubes V504 and V503 (fig. 34) for maximum ringtime.

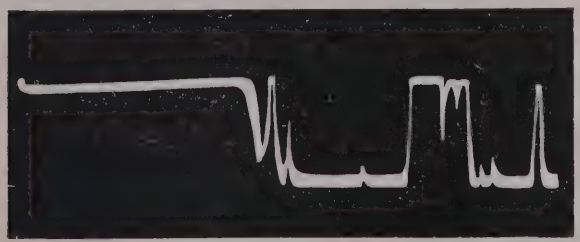
m. Readjust the signal mixer-local oscillator coupling (*i* above) for a red-line reading on the test meter. Lock the coupling adjustment, and place the TEST SELECTOR switch on the receiver-transmitter in the OFF position.

n. Readjust C305 (*g* above) for maximum ringtime.

Note. Best results are obtained if a nonmetalic (such as fiber) screwdriver is used.

o. Turn the clamping screws to loosen the two clamps which hold duplexer assembly RF503 to the coaxial line RF501 (fig. 34) and slowly slide RF503 in either direction until maximum ringtime is obtained. Securely tighten the two clamps.

Note. This assembly seldom needs adjustment unless the transmitter frequency is changed or the magnetron is replaced.



TM1167-20-89

Figure 14. A-scope presentation showing appearance of echo box signal with controls set for normal operation.

p. Turn the RANGE MARKS MILES switch (fig. 55, TM 11–1167–10) to the ON position, and measure the ringtime (fig. 67, TM 11–1167–10). There are 10,000 yards (approximately 5 nautical miles) between markers on the A scope when the A RANGE SELECTOR switch is placed in the 20-mile position.

(1) A slight readjustment of the RECEIVER GAIN control may improve the ringtime. Approximately ¼ inch of grass should appear on A scope.

(2) Compare this measured ringtime with the expected ringtime, which can be determined by following instructions in TM 11–1262, Test Set TS–172A/UP. A ringtime of approximately 12 miles should be obtained when the transmitter frequency is 1,280 mc.

q. With the echo box TUNE-READ RINGTIME lever in the TUNE position, detune the echo box by turning the tuning knob until the meter on the echo box indicates zero microamperes.

r. Turn the ANTENNA ROTATE control (fig. 55, TM 11–1167–10) and allow the antenna to rotate while observing the ppi scope.

s. Adjust the ppi VIDEO GAIN (fig. 55, TM 11–1167–10) for the desired signal intensity.

t. If iff equipment is being used, adjust the IFF VIDEO control (fig. 55, TM 11–1167–10) on Azimuth-Range Indicator IP–141/TPS–1D as follows:

(1) Loosen the lock nut on the IFF VIDEO control.

(2) Adjust the IFF VIDEO control for the desired level of iff signals, as seen on the ppi scope and lock the control.

14. Receiver Alinement, Mti Operation

Note. All locked controls should be relocked after adjustment.

a. Before proceeding with the mti receiver alinement, complete the normal receiver alinement and check controls listed below for positions indicated.

Control	Unit	Position
ANTIJAM	Indicator	OFF
RANGE SELECTOR (both controls).	Indicator	20
TRIGGER	Modulator	EXTERNAL

b. Place the TEST SELECTOR switch on the receiver transmitter in the COHO position, and adjust the coho mixer-local oscillator coupling by turning the coho mixer coupling adjustment (fig. 34) for a red-line reading on the test meter located above the TEST SELECTOR switch after loosening the knurled ring-nut which locks the coupling adjustment. If this adjustment fails to produce an indication of crystal current, check for a missing or improperly seated coho mixer crystal (CR502), which is inserted in the coho mixer assembly (RF502), adjacent to the coho mixer coupling adjustment (fig. 34, par. 38).

Note. Coho crystal current indication can also be observed on the TUNING METER located on the indicator (fig. 55, TM 11–1167–10).

Caution: Before sliding the receiver-transmitter into its case, secure the bottom access door.

c. Press the RADIATE OFF button (fig. 55, TM 11–1167–10).

d. Adjust controls 1 through 5 on the front of the signal comparator, following TEST INSTRUCTIONS given on the signal comparator (fig. 58, TM 11–1167–10).

Note. It may be necessary to readjust these controls once or twice during the alinement procedure. If it is impossible to obtain a red-line reading on the TEST METER (fig. 58, TM 11–1167–10) when adjusting No. 2 control (COHO LEVEL), adjust C361 inside the signal comparator for a red-line reading (fig. 30).

e. Place the OPERATION SELECTOR switch on the signal comparator in the MTI position, and press the RADIATE ON button.

f. Inside the signal comparator, adjust R1365 (fig. 30) as follows.

(1) Turn R1365 in a ccw direction until a double image appears on the A scope (fig. 15).

Note. To obtain a suitable image, it may be necessary to advance the setting of R3306 inside the signal comparator (fig. 30).

(2) Turn R1365 cw until the two images coincide.

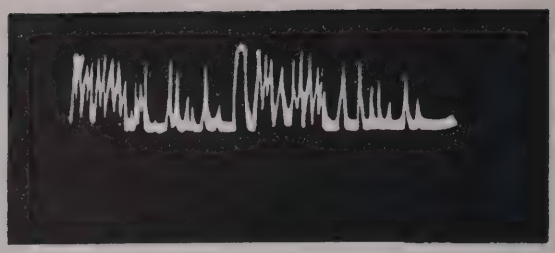


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Figure 15. A-scope presentation showing misadjustment of R1365.

(3) Turn R1365 cw an additional ⅛ turn.

Note. Turning R1365 cw beyond the point where the two images coincide is necessary for proper synchronization of a vital stage in the mti circuitry.

g. Use one of the following methods ((1)–(3) below) to adjust C361 inside the signal comparator. Use the method which is best adapted to your situation.

(1) *Echo box method.*

(*a*) Place the OPERATION SELECTOR switch on the signal comparator in the COHO ADJUST position.

Note. An alternate position is the REMOTE position, provided that the OPERATION switch on the indicator is placed in the COHO. ADJ. position.

(*b*) Tune the echo box (par. 13*e*).

(*c*) Turn C361 until several square waves appear on the A scope where ringtime normally appears.

Note. Best results are obtained if a nonmetallic (such as fiber) screwdriver is used.

(*d*) Adjust C361 for a minimum number of square waves. Maximum grass should appear on the A scope at this setting of C361. If not, readjust C305 and/or the local oscillator frequency (par. 13).

(*e*) Detune the echo box.

(2) *Moving-target method.*

(*a*) Place the OPERATION SELECTOR switch on the signal comparator in the REMOTE position and place the OPERATION switch on the indicator in the NORM position.

(*b*) Turn the ANTENNA ROTATE control and position the ppi sweep on a moving target.

(*c*) Place the OPERATION switch on

the indicator in the COHO, ADJ. position.

(*d*) Adjust C361 for maximum target amplitude, maximum grass and a solid baseline beneath the target on the A scope. These three indications should occur at the same setting of C361. If not, readjust C305 and/or the local oscillator frequency (par. 13). Then readjust C361. If a solid base line does not appear beneath the target, it is possible that the target is stationary. Locate another moving target and repeat the procedure.

Note. This adjustment must be performed rapidly since echo returns from moving targets are utilized.

(3) *Ground clutter method.*

(*a*) Place the OPERATION SELECTOR switch on the signal comparator in the NORMAL position, or place this switch in the REMOTE position and the OPERATION switch on the indicator in the NORM position.

(*b*) Turn the ANTENNA ROTATE control, and rotate the antenna to a position where a considerable amount of ground clutter appears on the scopes.

(*c*) Place the OPERATION SELECTOR switch on the signal comparator in the COHO ADJUST position ((1) (*a*) above), and adjust C361 to the setting that causes bright spots to appear along the base line of the A scope in the region of ground clutter. Maximum grass should occur at this setting of C361. If not, readjust C305 and/or the local oscillator frequency (par. 13).

h On the signal comparator, adjust the COHO SYNCH control (fig. 58, TM 11–1167–10) as follows:

(1) Turn the COHO SYNCH control completely ccw.

(2) Turn the COHO SYNCH control cw slightly past the point where a horizontal jump or shift (locking-in action) of the ground clutter is observed on the A scope.

i. Place the OPERATION SELECTOR switch on the signal comparator in the MTI position, and adjust R3306 inside the signal comparator (fig. 30) for a grass level of one-fourth of the saturation level on the A scope.

Note. This corresponds to a grass level of approximately one-fourth inch.

j. Turn the ANTENNA ROTATE control, and rotate the antenna to a position where a large amount of ground clutter appears on the scopes.

k . On the signal comparator, adjust the MTI BALANCE control (fig. 58, TM 11–1167–10) for minimum ground clutter, and readjust the AMPL. BALANCE control (fig. 58, TM 11–1167–10) for minimum ground clutter on the A scope.

Note. The echo box may be used for this adjustment. If used, adjust the MTI BALANCE control and the AMPL. BALANCE control for maximum cancellation of the ringtime pattern on the A scope.

l. Readjust R3306 (*i* above).

m. Place the OPERATION SELECTOR switch on the signal comparator in the REMOTE position and the OPERATION switch on the indicator in the MTI position. On the indicator, adjust the RECEIVER AMPL BALANCE and MTI BALANCE controls (fig. 55, TM 11–1167–10) for minimum ground clutter (fig. 60). If there is very little ground clutter cancellation, repeat the mti alinement.

15. Azimuth Orientation

a. Antenna Placement.

(1) On Azimuth-Range Indicator IP–141/TPS–1D, while transmitting and with the controls set for normal operation, turn the ANTENNA ROTATE control (fig. 55, TM 11–1167–10).

(2) Rotate the antenna until a target of known azimuth is in the antenna line-of-sight axis. The target will then appear as a bright spot on the ppi sweep.

Note. To obtain a suitable known-azimuth target, if this information is not provided, visual azimuth measurement with a compass should be taken on the most distant target which also stands out clearly on the ppi scope. To obtain an azimuth angle with respect to true north, angle of declination must be taken into account.

b. AZIMUTH Control Adjustment.

(1) Lift upward on the AZIMUTH control

latch (fig. 59, TM 11–1167–10) at its left side.

(2) Push the AZIMUTH control knob inward and rotate until the direction of the sweep on the ppi scope (indicated by the ppi azimuth scale) corresponds to the known azimuth of the selected target (fig. 59, TM 11–1167–10).

Note. When the cursor assembly, contained in the reserve parts chest, is placed over the ppi screen, bearings can be taken by orienting the cursor line on the cursor assembly amber filter to intersect the center of a target (fig. 59, TM 11–1167–10). The DIMMER control (fig. 55, TM 11–1167–10) may be adjusted until the azimuth scale is readable.

16. Installation Performance Tests

To insure that the radar set is in optimum operating condition, certain performance tests must be made on the equipment after it has been alined and adjusted.

a. Transmitter Power Output Measurement. Summation Bridge AN/URM–23 (fig. 16) is used to measure the average power output from the transmitter. Refer to operating procedures in TM 11–5128, Summation Bridge AN/URM–23. For assistance in making computations when measuring the transmitter power output, refer to TM 11–759, Theory and Measurement of Pulse Radar System Performance. Summation Bridge AN/URM–23 consists of Summation Bridge TS–730/URM and Power Measuring Kit MX–1309/URM–23. The power measuring kit contains attenuators to allow extension of the range of power measurements; one RF bolometer mount with an element which is power-sensitive; one adapter connector for the purpose of coupling an RF cord to an attenuator or the RF bolometer mount; one RF cord for the purpose of coupling RF power from the source through the adapter connector to an attenuator or the RF bolometer mount; fastening screws for the purpose of coupling together the flanges on the adapter connector, attenuators, or RF bolometer mount, as necessary; spare bolometer elements; and a set of attenuator calibration cards. The calibration cards give, by attenuator serial number, the actual attenuation values of the attenuators and deviations from nominal attenuation at three frequencies in addition to correction factors for ambient temperature. After periods of long disuse, refer to TM 11–5128 for preliminary operation test of the summation bridge.

Caution: Contents of the power measuring kit, especially the attenuators, are very fragile.

(1) Connect the RF bolometer mount to the input cable of Summation Bridge TS–730/URM. Connect the 20-db attenuator, adapter connector, and RF cord. Make certain that fastening screws are very tight.

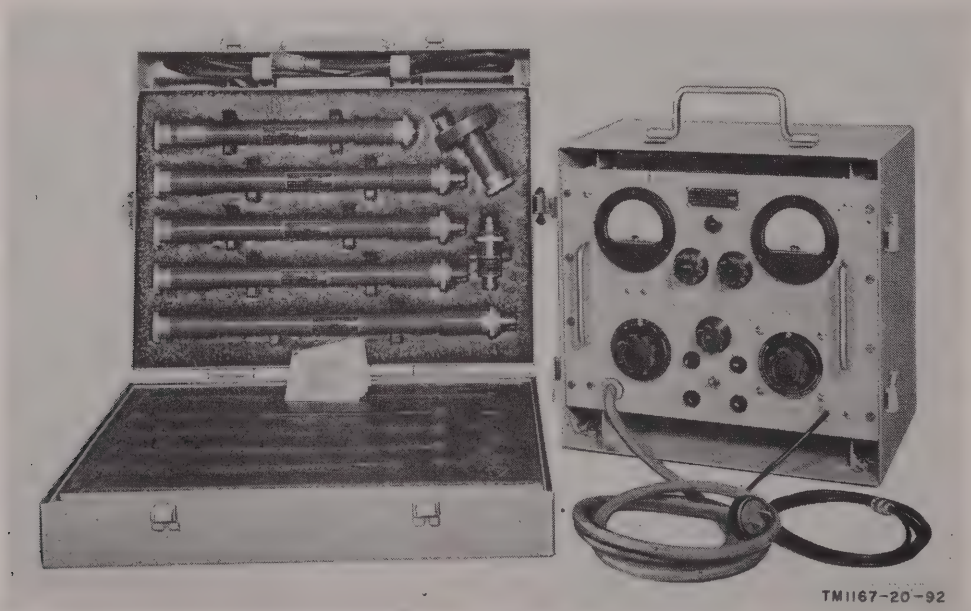


Figure 16. Summation bridge AN/URM–23.

Caution: Since the bridge will be damaged by power in excess of 50 milliwatts, when measuring the AN/TPS–1D transmitter power output, use the 20-db attenuator first. This affords the required measure of protection for the bolometer element in the bridge. If the reading on the black scale of the power meter, located on the right side of the ADJUST CALIBRATION control, is less than 5 milliwatts ((9) below), substitute the 10-db attenuator for the 20-db attenuator and repeat the transmitter power output measurement.

(2) Connect the plug on the power cable to one of the convenience outlets on the radar set (par. 3*d*).

(3) Turn the ON-OFF switch to ON, turn the selector switch to SET ZERO and allow a 20-minute warmup period.

(4) Refer to the proper attenuator calibration card, and set the COMPENSATE ATTENUATOR dial to the algebraic sum of corrections on the card for frequency and temperature. To determine the corrections, since the correction values given are for frequencies above and below the AN/TPS–1D transmitter frequency, it is necessary to interpolate.

Note. The transmitter frequency may be obtained from the echo box. This reading should be approximately the same as that obtained from Signal Generator TS–419/U (*b* (14) below).

(5) With the selector switch in the SET ZERO position, adjust the SET ZERO control until the pointer on the zero-center galvanometer, located on the left side of the SET ZERO control, is centered at 0.

(6) Rotate the selector switch to the CALIBRATION LEVEL position, and note the reading on the nonlinear red scale on the power meter.

(7) Rotate the selector switch to the ADJUST CALIBRATION position, and adjust the ADJUST CALIBRATION control until the same value indicated in (6) above appears on the black scale of the power meter.

(8) Connect the RF cord to RF TEST jack J501 (fig. 57, TM 11–1167–10) on Radar Receiver-Transmitter RT–212/TPS–1D, and while transmitting, rotate the selector switch to the ADJUST BALANCE position. Adjust the ADJUST BALANCE control until the pointer on the zero-center galvanometer is centered at 0 after stabilization.

Note. If the selector switch is left in the CALIBRATION LEVEL or ADJUST CALIBRATION position for more than a few seconds, it is recommended that the switch be returned to the SET ZERO position and that the procedures outlined in (5) through (8) above be repeated for maximum accuracy of measurement. Do not connect RF power to the summation bridge until the action outlined in (7) above has been completed.

(9) Read RF power on the black scale of the power meter. This reading indicates the strength of the signal at the bolometer element in the RF bolometer mount. To determine the average transmitter output power from the radar set, take into account the attenuation of the attenuator being used and the attenuation of the RF cord and the directional coupler at RF TEST jack J501 on the receiver-transmitter. Attenuation values at three frequencies are stamped on a metal tag attached to the RF cable. As attenuator compensation for frequency and temperature has already been taken into account when setting the COMPENSATE ATTENUATOR dial ((4) above), use the nominal value, such as 20 db or 10 db, of the attenuator being used in the computations below. Use directional coupler output characteristic curve (db) on figure 17 to determine the directional coupler attenuation. Convert the reading on the black scale of the power meter, which is in milliwatts, to a dbm reading. Refer to conversion chart in TM 11–759. An example of computing the average transmitter output power from the radar set is given below.

Converted reading on black scale of power meter 7.5 dbm.
Minus attenuator nominal value —20.0 db.
Minus RF cable attenuation —.5 db.

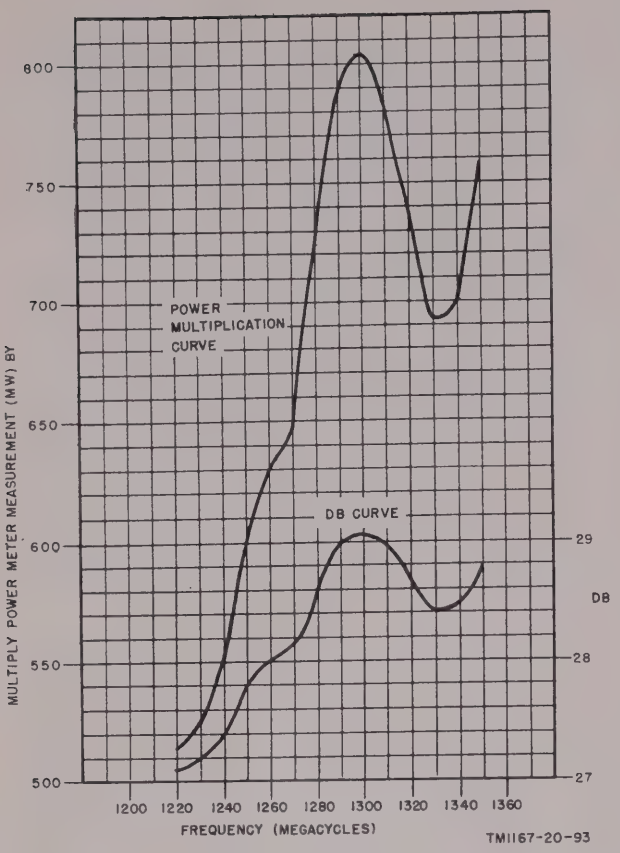


Figure 17. Directional coupler output characteristics.

Minus directional coupler attenuation. —28.8 db.

Equals measured average power___56.8 dbm.

(10) Determine the peak transmitter output power by adding the duty-cycle figure (decibels) of the radar set to the measured average power ((9) above). As the pulse rate of the radar set is 400 pulses per second when the set is operating normally and the pulse width is 2.0 micro-seconds, the duty-cycle figure is 31 db. The rated peak transmitter output power (optimum) is 87.6 to 87.9 dbm for the AN/TPS–1D. The minimum acceptable peak transmitter output power is 86.5 dbm. If the measured peak transmitter output power is too weak, troubleshooting is required. An example of computing the peak transmitter output power from the radar set is given below.

Measured average power_____56.8 dbm
Add duty-cycle figure_____31.0 db
Equals measured peak power_____87.8 dbm

(11) Shut down the test equipment.

Caution: Disconnect the RF bolometer mount from the test equipment input cable only after the test equipment has been deenergized.

b. Minimum Discernible Signal Measurement. Signal Generator TS–419/U (fig. 18) is used for providing an accurate signal source when measuring the minimum discernible signal. Refer to the operation and adjustment procedures for pulsed operation using external synchronization in TM 11–5553, Signal Generator TS–419/U. For assistance in making computations when measuring the performance of the receiver, refer to TM 11–759.

(1) While transmitting and with the radar set controls set for normal operation and a range of 20 miles, rotate the antenna until a minimum amount of clutter appears on the A scope.

(2) Connect power cable between the uhf generator and one of the convenience outlets on the radar set (par. 3*d*).

Note. With this connection, power is supplied to space heaters in the uhf signal generator. These heaters will remain energized until the POWER switch is placed in the ON position or until the power cable is disconnected.

(3) Place the POWER switch in the ON position. Allow a 10-minute warmup period.

(4) Connect the video cable between the SYNC IN jack on the uhf signal generator and J153 (fig. 54, TM 11–1167–10) on Radar Modulator MD-144/TPS–1D.

(5) Connect the RF cable between the R–F OUTPUT jack on the uhf signal generator and RF TEST jack J501 on the receiver-transmitter.

(6) With the SIGNAL FREQUENCY control on the uhf signal generator set to the approximate transmitter frequency of the radar set, set the selector switch to ZERO SET and adjust the ZERO SET control until the meter on the uhf signal generator reads exactly at the meter dial line marked ZERO SET.

(7) Set the selector switch to CW and adjust the POWER SET control until the

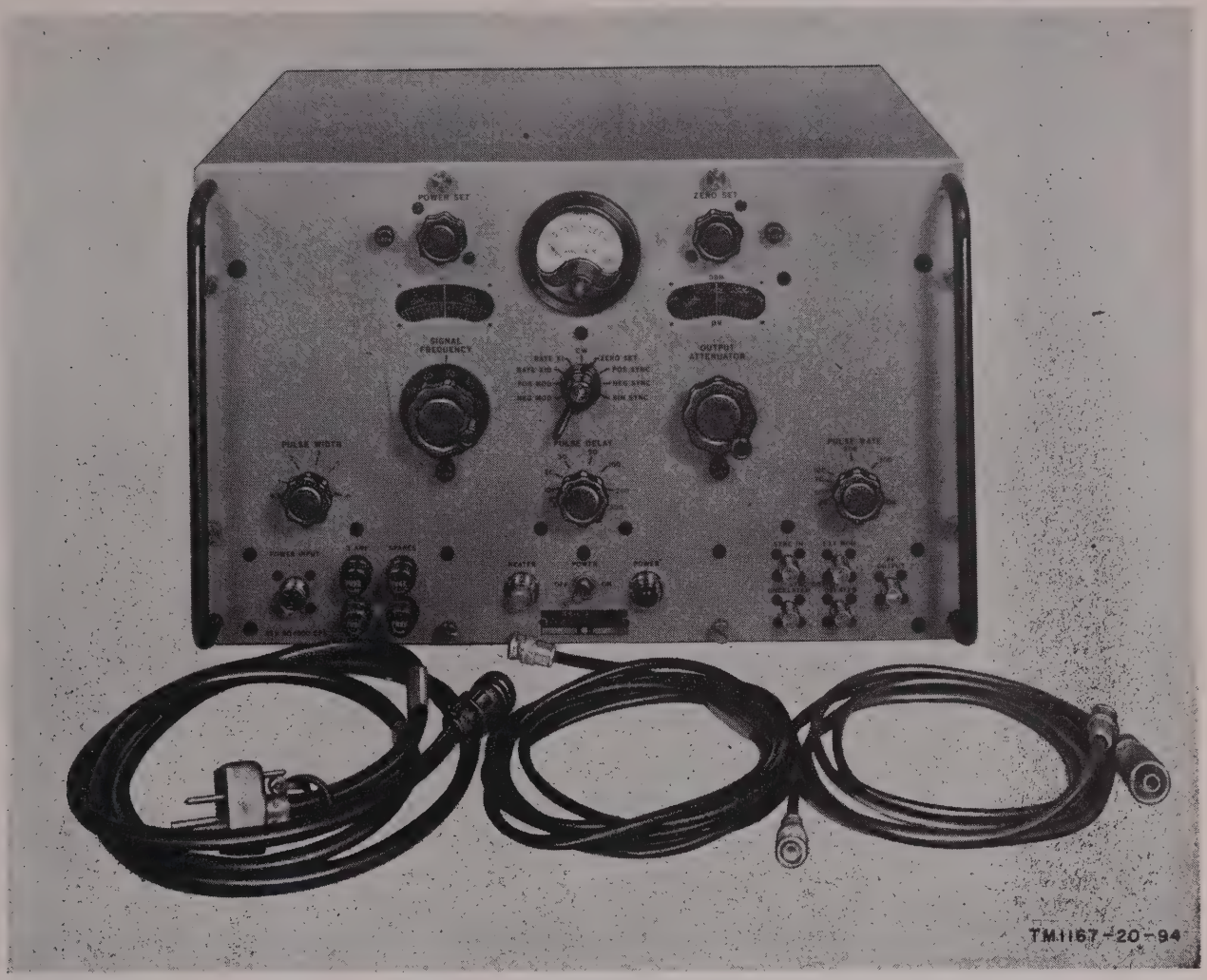


Figure 18. Signal generator TS–419/U.

meter reads exactly 0 dbm (half-scale).

Note. This establishes a reference level which allows the output power to be read directly from the OUTPUT ATTENUATOR dial scale.

(8) Repeat the ZERO SET and POWER SET control adjustments, as these adjustments interact.

(9) Set the selector switch to POS SYNC.

(10) Set the PULSE WIDTH control to 2 microseconds, and set the PULSE DELAY control to approximately 100 microseconds.

(11) Set the OUTPUT ATTENUATOR to a reading of –3 DBM on the dial scale.

(12) With a ¼-inch grass level on the A scope, adjust the SIGNAL FREQUENCY control on the uhf signal generator for a maximum amplitude pulse on the A scope.

(13) By adjusting the OUTPUT ATTENUATOR control, attenuate the output signal until the pulse amplitude decreases substantially on the A scope. Readjust the SIGNAL FREQUENCY control for a maximum amplitude pulse on the A scope.

(14) Adjust the OUTPUT ATTENUATOR control until the pulse is barely visible above the grass level on the A scope. The reading on the OUTPUT ATTENUATOR dial scale indicates the strength of the signal at the R–F OUTPUT jack on the uhf signal generator. To determine the minimum discernible

signal at the radar set, the RF cable attenuation, which is given in TM 11–5553, and the attenuation of the directional coupler at RF TEST jack J501 on the receiver-transmitter must be taken into account. Use the signal frequency indicated on the MC dial located above the SIGNAL FREQUENCY control on the uhf signal generator, and directional coupler output characteristic curve on figure 17, to determine the directional coupler attenuation. The rated minimum discernible signal is —102.3 to —104.0 dbm for the AN/TPS–1D. If the measured minimum discernible signal is too strong, troubleshooting is required. An example of computing the minimum discernible signal is given below.

OUTPUT ATTENUATOR dial reading.	—73.0 dbm
Plus RF cable attenuation	—1.2 db
Plus directional coupler attenuation.	—28.8 db
Equals measured minimum discernible signal.	—103.0 db

CHAPTER 3
MAINTENANCE INSTRUCTIONS

Section I. GENERAL MAINTENANCE PROCEDURES

17. Scope of Maintenance

Scope of maintenance duties performed by the second echelon repairman is limited by the available tools, materials, test equipment, and spare parts. This maintenance of Radio Set AN/TPS–1D consists of the following:

a. Preventive maintenance (par. 19).

b. Refinishing of painted surfaces (par. 19).

c. Repair of frayed and cut cable insulation (par. 19).

d. Burnishing of easily accessible relay contacts (par. 21).

e. Cleaning of accessible slip rings (par. 21).

f. Lubrication (par. 22).

g. Visual inspection (par. 23).

h. Sectionalization, localization, and isolation of trouble (pars. 24–31).

i. Testing and replacement of tubes (par. 32–37).

j. Replacement of plug-out crystals, fuses, and lamps (pars. 19, 30, and 38).

k. Performance of checks in accordance with the equipment performance checklist (pars. 26–29).

l. Alinement and adjustment of the radar set, including:

(1) Equipment stack leveling and securing (par. 19).
(2) Rigid RF line alinement (par. 20).
(3) Time-delay relay K401 adjustment (par. 7).
(4) Fixed Power Transformer Autotransformer TF–223/G output adjustment (par. 7).
(5) Magnetron aging (par. 8).
(6) Pulse repetition rate adjustment (par. 39).
(7) Modulator high-voltage adjustment (par. 8).
(8) Protective relay balance adjustment (par. 8).
(9) Magnetron frequency adjustment (par. 8).
(10) Power supply adjustments (par. 9).
(11) Indicator alinement, including adjustment of the antenna speed (par. 12).
(12) Receiver alinement, normal operation (par. 13).
(13) Receiver alinement, mti operation (par. 14).
(14) Azimuth orientation (par. 15).

m. Measurement of the transmitter power output (par. 16*a*).

n. Measurement of the receiver sensitivity (minimum discernible signal measurement) (par. 16).

18. Tools, Materials, and Test Equipment Required

The tools, materials, and test equipment required for second echelon maintenance are listed below. The tools and materials contained in Tool Equipment TE–113 are listed in the Supply Manual SIG 6 TE–113.

a. Tools.

(1) Tool Equipment TE–113.
(2) Fuse puller (fig. 19). This fuse puller is stored behind the access door on the power supply front panel.
(3) Strap wrench (fig. 19). This strap wrench is used to tighten knurled fittings. It is stored in the spare parts case.
(4) Special tower assembly tool (fig. 19). This tool is used in conjunction with the strap wrench to seat units, in a tower assembly, that have sprung frames (fig. 22, TM 11–1167–10). It is stored in the spare parts case.

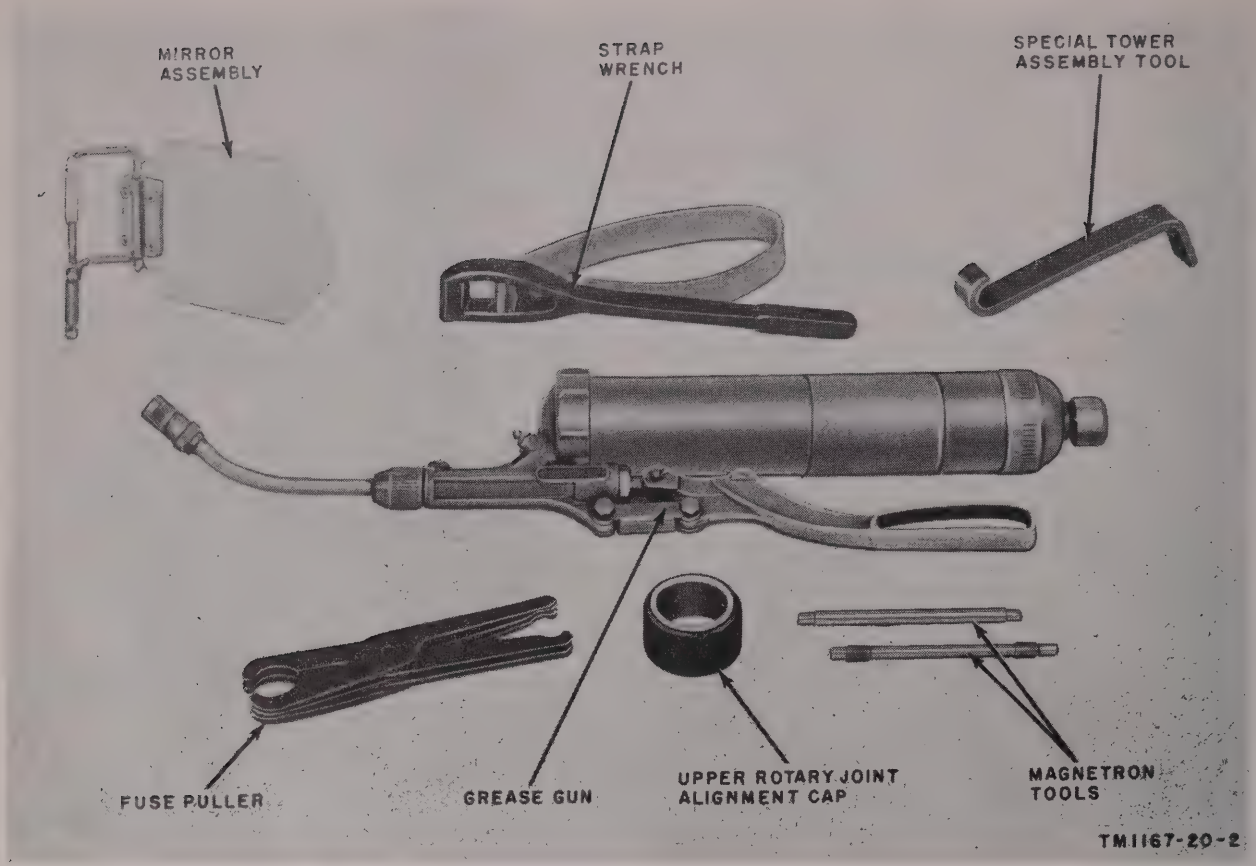


Figure 19. Tools required for organizational maintenance.

(5) Leveling rod (jack tool). This tool is used to raise or lower the leveling jacks on Mounting MT–960/TPS–1D when the equipment stack is not level (fig. 25, TM 11–1167–10). It is stored in the spare parts case.

(6) Upper rotary joint alinement cap, stock No. 2Z1607–261 (fig. 19). This cap is used to align the inner conductor of the RF line which runs through the antenna base spindle shaft. It is stored in the spare parts case.

(7) Magnetron tool (fig. 19). This tool is used to loosen or tighten the ring nut on the magnetron output connector fitting to allow removal or replacement of the magnetron. It is stored in the spare parts case.

(8) Mirror assembly (fig. 19). This mirror assembly is used to facilitate the viewing of scope patterns when adjusting the radar system. It is stored in the spare parts case.

(9) Grip type nozzle grease gun (fig. 19). This grease gun is used to apply grease to alemite hydraulic fitting on the antenna base.

b. Materials.

(1) Materials contained in Tool Equipment TE–113 include cleaning cloth, abrasive cloth, fine sandpaper, rubber tape, friction tape, rosin-core solder.

(2) Lubricating oil, gear, (GO–90), all temperatures.

(3) Grease, automotive and artillery (GAA), all temperatures.

(4) Zinc-chromate primer, specification JAN–P–735.

(5) Finish paint, specification 52–E–12.

(6) Dishwashing compound.

(7) Lubricating oil, specification NS–3050, stock No. 14–P–2662.

(8) Cleaning compound, stock No. 7930–395–9542.

c. Test Equipment.

Nomenclature	Common name	Manual	Use
Multimeter TS–352B/U	Multimeter	TM 11–5527A	Voltage and continuity measurements.
Summation Bridge AN/URM–23	Summation bridge	TM 11–5128	RF power output measurement.
Signal Generator TS–419/U	μhf signal generator	TM 11–5553	Minimum discernible signal measurement.
Electron Tube Test Sets TV–7B/U	Tube tester	TM 11–5083	Electron tube tests.
Oscilloscope AN/USM–24C	Oscilloscope	TM 11–5103A	Wave-form checks at key points.
Test Set TS–172A/UP	Echo box	TM 11–1262	Alinement aid and receiver sensitivity measurement.
Variable Power Transformer TF–171/USM *.	Variac	TM 11–1250	Magnetron aging.

* Electrical Power Cable Assembly CX–3641/U must be attached to the variac (fig. 7).

19. Preventive Maintenance

a. DA Form 11–238. DA Form 11–238 (figs. 1 and 2) is a preventive maintenance checklist to be used by the second echelon repairman. Items not applicable to the equipment are lined out in the figure. References in the ITEM block in the figure are to paragraphs that contain additional maintenance information pertinent to the particular item. Instructions for the use of the form appear on the front of the form. The second echelon repairman will perform monthly maintenance on all checklist items except for items that are struck out and items 5, 8, and 26. Weekly maintenance will be performed on items 5, 8, and 26.

b. Supplementary Maintenance Information. The information in this subparagraph is supplementary to DA Form 11–238. The item numbers refer to the ITEM numbers on the form. Obtain permission to disconnect power as required for preventive maintenance checks.

Warning: When power to the equipment is disconnected, some capacitors still may retain voltage of dangerous potential. Before touching exposed electrical parts, short circuit the part to ground.

Item	Maintenance procedure
1	Refer to paragraph 5, TM 11–1167–10, and check the completeness of the equipment with the table of components. Check for missing pluck-out items. All fuses and blown-fuse indicators (type NE–51 lamps) are located on the front panel of the power supply. A threaded type lens covers each NE–51 lamp. Fuse sizes are shown on this front panel. locations of high-voltage warning lights (type 991 tubes with the exception of I 610 (type NE–51 lamp) in the indicator) are shown in figures 3, 8, 13, 27, 31 and 34. An additional modulator high-voltage warning light (I 151) is located on the left side of the chassis. Locations of ppi scale lights (type 47 lamps) are shown in figure 23. The power-on indicator light (type 47 lamp) is shown in figure 13. The location of TY501 (type 7 H 11 thermal resistor), which is mounted in a tube socket is shown in figure 33. Locations and types of tubes are shown in figures 23 through 32, 34 and 35. All the shields must be locked in place. See paragraph 6 for applicable checks and precautions.
2	Use a clean cloth to remove dust, dirt, moisture, and grease from all front panel controls. If necessary, wet the cloth with cleaning compound and clean the parts; then wipe them dry with a dry clean cloth. Shut down equipment so that loosened dirt will not be sucked into filters by blowers. To gain access to the antenna in a single-stack installation, see paragraph 6*a*(8). ***Warning:*** Cleaning compound is inflammable and its fumes are toxic.
5	See paragraph 6 for applicable external tower checks. Make certain that the four antenna captive mounting bolts (fig. 9, TM 11–1167–10) are tight. Maintenance of RF transmission lines is explained in paragraph 20. See paragraph 74, TM 11–1167–10 for special cleaning procedures. After periods of high winds, check the security of the equipment stack.

Item	Maintenance procedure
6	When rust and corrosion are discovered, clean and refinish as explained in paragraph 77, TM 11–1167–10.
7	Replacement of connectors on signal and multiconductor cables will be performed by a higher echelon repairman. Repair frayed and cut cable insulation by covering the damaged area with rubber tape and then with friction tape. Resolder improperly soldered or loose soldered connections. Use pliers to dissipate excessive heat when soldering.
8	In addition to weekly checks, check the guy wires and accessories shown in figure 32, TM 11–1167–10 after periods of high winds and storms. Allow just enough guy wire tension to keep the tower steady. In conjunction with a check of the guy wires, check the tower weight distribution, the adequacy of the supporting ground, the seating of guy anchors, the level of the tower, and the security of the electrical ground cable (par. 6). The leveling rod (fig. 25, TM 11–1167–10) is required to level the tower. Broken guy wires and improper tension can result in improper seating of tower unit cases and sprung unit frames. It may be necessary therefore, to use the special tower assembly tool (fig. 19) in conjunction with the strap wrench to reseat tower units (fig. 22, TM 11–1167–10).
11	Clean the air filters as explained in paragraph 74, TM 11–1167–10.
13	After periods of high winds, rain, and snow, check the shelter carefully for undue canvas strain, tears, fraying, and abrasion. See paragraph 6*b* for additional shelter checks.
15	See item 1 above for location of lamps and fuses. Interunit cabling connections are shown in figure 52, TM 11–1167–10. Internal cabling connections in the signal comparator are shown in figures 22 and 30. Internal cabling connections in the receiver-transmitter are shown in figure 34. Inspect fuse ends carefully for corrosion, which may reduce the cross section area enough to cause failure at a lower-than-rated current. Use sandpaper to remove corrosion at fuse ends. Inspect multiconductor and coaxial cable connectors for dirt, corrosion, and tightness of contacts. Clean with a dry cloth. Scrape off corrosion on contacts with a knife, using light pressure.
16	See paragraph 21*a*.
18	Clean high-voltage insulators with a clean, dry cloth and cleaning compound.
19	Carefully inspect terminal boards for bits of solder, wire, and dirt. Use extreme care when cleaning.
20	When loose connections or disconnected leads are found, correct the condition and check for correct connections by comparing the terminal strip markings with the lead markings.
21	Clean the large glass inclosed resistors and the insulators with a clean dry cloth. Inspect electrolytic capacitors for leakage and bulging sides.
22	Wipe components clean with a dry cloth.
23	See paragraph 21*b* for synchro and deflection coil (L601) assembly maintenance. Maintenance of the antenna drive motor will be performed by a higher echelon repairman.
25	Give special attention to gaskets for unit case covers.
26	See item 6 above for refinishing of painted surfaces. See paragraph 6 for applicable checks. This inspection will be performed each week.
27	Follow the equipment performance checklist (par. 26) to check for normal operation. Check the performance of the radar set (par. 16).
—	

20. Maintenance of RF Transmission Lines

An inspection of RF transmission lines is required each week. After periods of rain or snow, care must be exercised to prevent damage to the RF system by moisture. The complete check requires disassembly of the system at various points to determine if moisture is present. When inspection reveals evidence of arcing and/or corrosion, the burned or corroded area must be cleaned and polished, and immediate action must be taken to remove the cause of the defect. Arcing and corrosion of RF transmission lines may be caused by improper connections, defective line sections, water in the lines, improper centering of inner conductors, or similar faults.

a. Initial Inspection. To make a thorough inspection of the RF transmission lines, it is necessary to disconnect RF754 and RF856 (fig. 32, TM 11–1167–10), RF851 and RF854 (fig. 31, TM 11–1167–10), and RF855, which is con-

nected between RF854 and the receiver-transmitter. Use the strap wrench (fig. 19) to loosen the knurled coupling fittings on the line sections. In addition, loosen clamps on line supports (fig. 31, TM 11–1167–10) for RF851 and RF854. Inspect the lines carefully for moisture, corrosion, bits of charred material, soot, and damaged contact surfaces. Inspect for dents in the rigid lines and external damage to flexible line RF854.

Caution: RF854 must not be bent too sharply. Deformation of the center conductor will result. This in turn can result in arcing, loss of output power, and a shutdown of the radar set.

b. Cleaning. Wipe the contact surfaces on the RF coaxial cables with a dry cloth. Polish until a smooth, glossy surface is obtained. Remove corrosion by rubbing the contact surfaces with canvas or similar material. Make certain that no moisture is left inside the lines.

c. Assembly and Final Inspection. Connect RF851, RF854, and RF855. Use the strap wrench to tighten the knurled coupling fittings, and tighten the line-support clamp. Make certain that the line sections meet properly. Check the centering of the RF751 inner conductor at the top of the spindle (fig. 30, TM 11–1167–10) on the antenna base. Use the upper rotary joint alinement cap (fig. 19). If the inner conductor is not properly centered, loosen the inner conductor adjustment clamp (fig. 31, TM 11–1167–10) and the inner conductor adjusting screw (fig. 8, TM 11–1167–10); center the inner conductor by coordinated adjusting at these two adjustment points, then tighten the adjustment clamp and adjusting screw. Connect RF754 and RF856 and follow the precautions given for the other line sections.

Caution: Improper assembly of RF line sections can result in unnecessary failure and deterioration.

21. Maintenance of Relays, Synchros, and Deflection Coil (L601) Assembly

a. Relay Maintenance. The second echelon repairman will inspect each month and, if necessary, clean the easily accessible relays listed in the chart below. A check for proper spring tension will be performed only by a higher echelon repairman. The contacts on all the relays listed except K152 and K402 are exposed. To expose the contacts on K152 and K402, it is necessary to remove the relay covers which are held in place with two screws. In addition, it may be necessary to remove tubes V401 through V406 (fig. 31) when cleaning K402. Inspect the contacts for dirt, corrosion, and pits. Burnish only if necessary with the burnisher contained in Tool Equipment TE–113. Replace all covers.

Relay	Unit	Figure No.
K152	Modulator	27
K402	Power supply	31
K701	Antenna base (servo amplifier)	29
K702	Antenna base (servo amplifier)	29
K703	Antenna base (servo amplifier)	29
K704	Antenna base (servo amplifier)	11
K705	Antenna base (servo amplifier)	29
K3300	Signal comparator	22
K3301	Signal comparator	22

b. Synchro and Deflection Coil (L601) Assembly Maintenance. The second echelon repairman will inspect each month and, if necessary, clean the synchros listed in the chart below and the deflection coil (L601) assembly (fig. 10). To expose B752 and B753, the antenna drive unit assembly cover on the antenna base (fig. 9) must be removed. To expose the brushes and slip rings on B602, B752, and B753, remove the protective covers at one end of the synchros. One screw holds the protective cover in place on B602 and B752. Three screws hold the protective cover in place on B753. To expose the brushes and slip rings on the deflection coil (L601) assembly (fig. 10), remove the assembly cover. Inspect the brushes and slip rings for dirt, corrosion, wear, and pitting. Clean and polish with a clean cloth. Replace all covers.

Note. Each synchro is held in place by a clamp which is secured by four clamp screws which must be tight. If the body of a synchro is inadvertently turned during the inspection and cleaning process, realignment of the synchros under the supervision of a higher echelon repairman is required. When replacing the antenna drive unit assembly cover, make certain that the gasket for this cover is seated properly and has no breaks.

Synchro	Unit	Figure No.
B602	Indicator	24
B752	Antenna base	9
B753	Antenna base	9

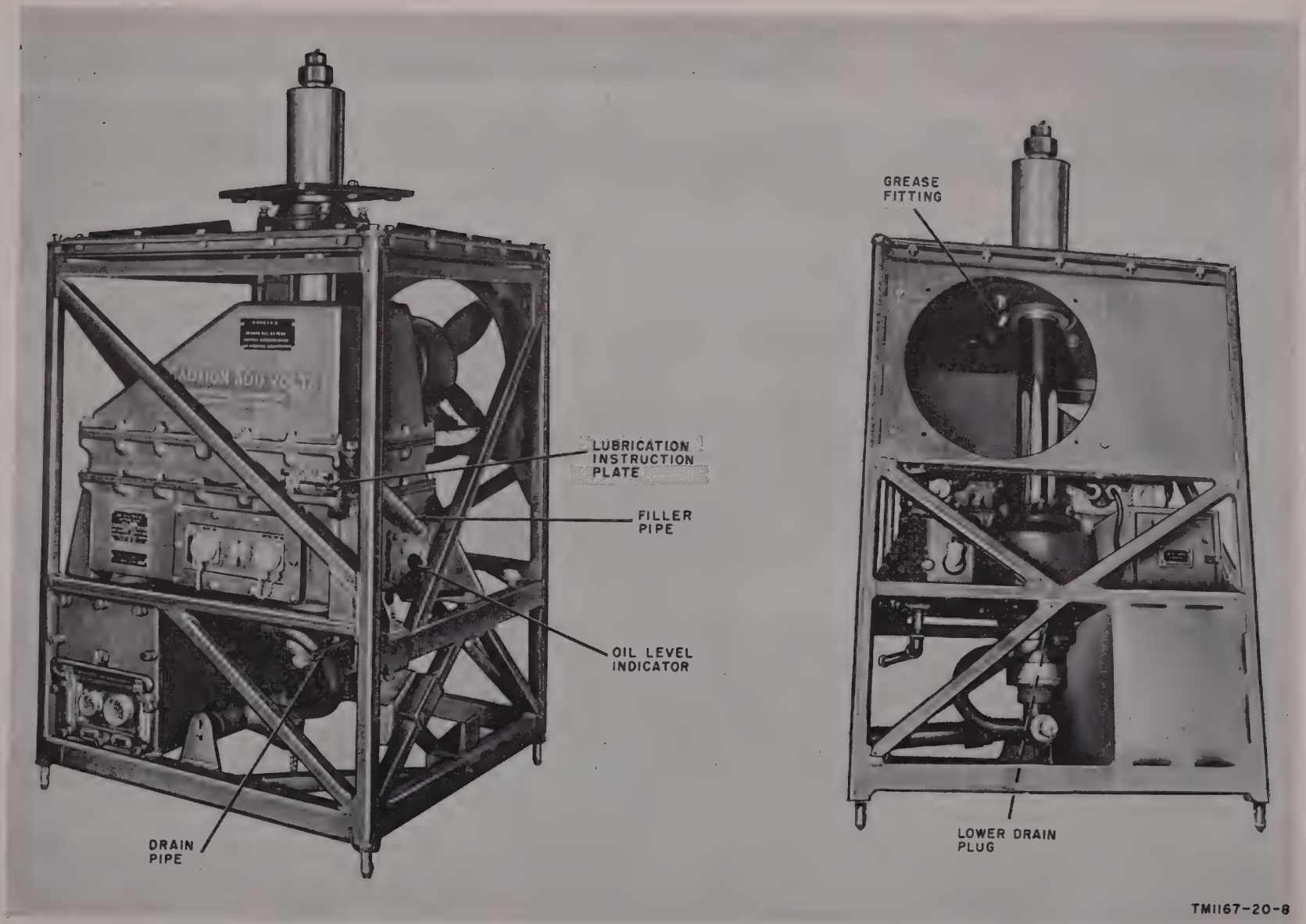


Figure 20. Lubrication details.

22. Lubrication

a. General. The only points requiring lubrication in Radio Set AN/TPS–1D are located in the antenna base. All blower motors have permanently lubricated sealed bearings. The ppi deflection coil yoke gearing does not require lubrication. In the chart (*b* below), the symbol S stands for a period of 6 months. The intervals given are for normal 8-hour day operation. For abnormal conditions or activities, intervals should be adjusted to compensate. For example, if the radar set must be operated 16 hours a day instead of 8, all lubrication periods have to be cut in half. Tools required for lubrication are a grip type nozzle grease gun (fig. 19) and an adjustable open end wrench. Lubricants required are listed in the chart below.

	Lubricant	Temperature
GO	Lubricating oil, gear, GO–90.	All
GAA	Grease, automotive and artillery.	All

b. Procedure. Lubricate in accordance with the procedure outlined in the chart below. All lubrication points are shown in figure 20.

Interval	Lubricant	Part lubricated	Procedure
S	GAA	Shaft ball bearing	Remove the cap on the alemite hydraulic grease fitting. Apply grease to the fitting. Use three strokes of the grip type grease gun. Replace the cap.
S	GO	Gear case	Remove the upper drain cap (¼" pipe cap) on the drain pipe. Use the adjustable open end wrench. Allow the old lubricant to drain out completely. Replace the drain cap. Remove the lower drain plug (⅛" pipe plug). Use the adjustable open end wrench. Allow the old lubricant to drain out completely. Replace the drain plug. Remove the filler plug (½" pipe plug) on the filler pipe. Use the adjustable open end wrench. Refill in accordance with instructions on the lubrication instruction plate on the antenna base until the oil is between the HIGH LIMIT and LOW LIMIT markings on the oil-level indicator.

Section II. TROUBLESHOOTING

23. Visual Inspection

Troubles in a radar set are sometimes caused by defects that are easy to see. A list of such defects follows. Check as many of these as may apply to the troubleshooting problem before using more involved procedures.

a. Sprung unit frames and damaged unit cases, resulting in improper operation of interlocks when units are closed.

b. Units improperly secured in their cases, allowing interlocks (par. 3) to open under slight shock or vibration.

c. Burnt-out fuses, indicated by illumination of blown-fuse indicators on the front of the power supply.

d. Improper position of switches and improper meter readings (par. 26).

e. Obvious damage or mechanical abnormalities, especially of the antenna and RF line sections.

f. Presence of dirt, corrosion, moisture, and bits of wire and solder.

g. Inadequate provisions for ventilation, especially in the antenna base (fig. 33, TM 11–1167–10).

h. Worn, broken, or disconnected cables, wire, and plugs.

i. Incorrect interunit cable connections (fig. 52, TM 11–1167–10) and internal cable connections (figs. 22, 30, and 34).

j. Loose tube shields and clamps, resulting in improperly seated tubes.

k. Unlit tube filaments, indicating defective or improperly seated tubes.

l. Cracked or charred resistors.

m. Bulging or leaking electrolyte capacitors.

n. Blistering of paint and other signs of overheating on transformers, chokes, potentiometers, and motors.

o. Discoloration of the insulation on wires. Under heavy overloads, it is possible for some wires to melt and produce no visible evidence other than a slight discoloration of the insulation surrounding the wire.

24. Sectionalization, Localization, and Isolation of Trouble

a. General. Sectionalization of trouble in Radio Set AN/TPS–1D consists of tracing the fault to the system or unit responsible for the abnormal operation of the radar set. Localization consists of tracing the trouble to the faulty assembly, subassembly, network, channel, circuit, or stage. For example, after trouble has been sectionalized to the signal comparing system in the signal comparator unit, the trouble may be localized to the delay channel followed by localization to the delay ampifiers and localization to one of the delay amplifiers. Isolation consists of tracing the trouble to the defective part or component after completion of localization. The second echelon repairman will perform only very limited isolation. When faults do occur in the radar set, the repairman must locate and correct them as rapidly as possible. It is seldom possible to observe a symptom of trouble and immediately diagnose the cause. Usually it will be necessary to perform the sequence of troubleshooting steps referred to as sectionalization, and isolation of trouble.

b. Procedure. When the cause of the failure is not known immediately, the defect usually can be sectionalized by following the systematic method used to put the radar set into operation, while keeping a close watch for abnormal indications such as faulty equipment meter readings or the failure of controls to function properly (par. 26). If the abnormal indication does not sectionalize the trouble, use a process of eliminating systems that are operating properly to discover the defective system. Localization and isolation can then be performed. Some faults, such as burnt-out resistors and selenium rectifiers, inoperative blowers, and RF arcing, can be located by sight (par. 23), smell, and hearing. The majority of faults, however, can be located only by making further checks. In addition to making use of the test equipment available to the second echelon repairman (par. 18), take advantage of the following troubleshooting data, which are supplied to help the repairman locate the trouble.

(1) Block diagram (figs. 37 and 40).
(2) Waveform diagrams (fig. 21).
(3) Illustrations of components.
(4) Interunit cabling diagram (fig. 52, TM 11–1167–10).
(5) Block diagram use (par. 49*a*).

25. Reference Data

The following chart provides figure reference data to identify and locate parts mentioned in the equipment performance checklist (par. 26).

Unit	Reference designation	Type of data	Fig. No.	
			TM 11–1167–10	TM 11–1167–20
Modulator	101–199 1101–1199	Unit location		38
		Trigger chassis location		8
		Tube locations, including locations of high-voltage warning lights (type 991 tube).		8, 27, 28
		Front panel controls	54	
		Interlock location		8
		Test points		8, 28
Receiver-transmitter	201–299 501–599	Unit location		38
		Tube locations, including locations of high-voltage warning lights (type 991 tube).		3, 32, 34, 35
		Thermal resister TY501		33
		Internal cable connections		34
		Front panel controls and instruments	56	

Unit	Reference designation	Type of data	Fig. No.	
			TM 11–1167–10	TM 11–1167–20
		Interlock location		3
		Test points		33
Signal comparator	301–399	Unit location		38
	1301–1399	Delay line		22
	2301–2399	Tube locations		30
	3301–339	Internal cable connections		30, 22
		Front panel controls and instruments	58	
		Interlock location		22
		Test point	58	
Power supply	401–499	Unit location		38
		Tube locations, including locations of high-voltage warning lights (type 991 tube).		31
		Fuse locations	56	
		Blown-fuse indicator lamp locations	56	
		Front panel controls and instruments	56	
		INTERLOCK SHORTING SWITCH location.		31
Indicator	601–699	Unit location		38
	1601–1699	Tube locations		23–26
	2601–2699	Ppi scale lights		23
		Power-on indicator lamp		13
		Front panel controls and instruments	55	
		Interlock location		23
		Test points		23–26
Antenna base	701–799	Test-point wave forms		21
		Unit location		38
		Servo amplifier location	8	
		Tube locations		29
		Front panel controls and instruments	8	
		Interlock location		11
		Test points		29

26. Equipment Performance Checklist

a. General. The equipment performance checklist is a step-by-step procedure based on the equipment starting, operating, and testing procedures for sectionalizing, localizing, and sometimes isolating trouble in the radar set. When using the checklist, start at the beginning and follow each step in order. If an abnormal indication is obtained, follow the procedures given in the *Corrective measures* column before proceeding to the next step. All the corrective measures which the second echelon repairman can perform are given in this column. If the corrective measures prescribed do not fix the radar set, troubleshooting is required by higher echelon. Note on the repair tag how the equipment performed and what corrective measures were taken, if the equipment is turned in for repair. For the location and identification of parts mentioned in the equipment performance checklist, refer to paragraph 25.

Note. Procedures for disabling interlocks when units are opened are explained in paragraph 3.

b. Checklist.

Caution: Observe all equipment high-voltage warnings.

Phase	Step	Unit	Action	Normal indication	Corrective measures
PREPARATORY	1	_____	Check for any obvious damage or abnormalities.		
	2	Power supply____	Check heater power link connections (par. 6*c*(10) and 6*c*(1)) for operation of unit chassis catches and catch releases.		
	3	_____	Check for proper interunit cable connections (fig. 52, TM 11–1167–10) and internal cable connections (figs. 22, 30, and 34). These connections must be tight.		
	4	Antenna base____	Check for open ventilation ports (fig. 33, TM 11–1167–10).		
	5	Antenna base____	Check oil level in antenna base gearcase	Oil level is between the HIGH LIMIT and LOW LIMIT markings on the oil-level indicator (fig. 8, TM 11–1167–10).	Lubricate in accordance with the lubrication procedure (par. 22).
	6	_____	Check applicable auxiliary equipment (pars. 79–83, TM 11–1167–10) instructions.		
	7	_____	Check seating of front panels on all units.		
	8	_____	Set controls as follows: POWER (indicator) at OFF. ANTENNA ROTATE (indicator) to ORPM. Safety switch (fig. 8, TM 11–1167–10) at ON. ANTI-JAM (indicator) at OFF. OPERATION (indicator) at NORM. TRIGGER (modulator) at EXTERNAL. TEST SELECTOR (receiver-transmitter) at MAG. FIL. OPERATION SELECTOR (signal comparator) at REMOTE.		

START

9	Power unit	Start the power unit, following instructions in TM 11–919 or other applicable literature.	Power unit starts and adjusts correctly.	See TM 11–919.
10	Power supply	After power unit has warmed up, check the no load readings of VOLTMETER M401 and LINE FREQUENCY meter M403.	VOLTMETER M401 reads approximately 115 volts ac. LINE FREQUENCY meter M403 reads from 384 to 416 cps.	Check applicable power literature. Check power cable and fittings. Check connections at Fixed Power Transformer Autotransformer TF–223/G (par. 7*g*), if used.
11	Indicator	Set POWER switch (indicator) to ON	Power-on indicator I 609, above the POWER switch, lights. Blowers B401 (power supply), B501 (receiver-transmitter), and B702 (servo amplifier in antenna base) are heard operating (par. 7). A spot of light appears on the ppi and A scopes. Test meter above TEST SELECTOR switch on the receiver-transmitter reads 65 to 83 percent of full scale.	Replace power-on indicator I 609 (type No. 47 lamp) (fig. 13). Check for illumination of blown-fuse indicators on front of power supply. Replace a blown fuse no more than once before taking action to discover the cause (par. 30). If no blower motors are heard operating, check relay K402 (fig. 31). If closed, check K402 contacts and clean (par. 21*a*) if necessary after removing power at the power unit. If open, flip POWER switch to OFF and ON once or twice to check for evidence of cut-out from loose contacts. If both scopes are completely blank, turn up the INTENSITY controls on the front of the indicator. Check +300-volt supply (par. 29). Check V626 by substitution. Check indicator high voltage at TP611 (—430 volts dc ±10 per cent), and TP612 (+300 volts dc ±10 percent), shown in figure 26, with the multimeter (20,000 ohms per volt). ***Warning:*** Do not operate the indicator with the phenolite cover removed from the high-voltage circuits alongside the A scope (shown removed in fig. 26). Keep clear of these circuits. If abnormally high voltages are indicated, higher echelon maintenance is required. If only one scope is completely blank with its INTENSITY control turned up, replace the dark tube (par. 37). If any high-voltage warning lights inside the units are not illuminated

Phase	Step	Unit	Action	Normal indication	Corrective measures
	11				when the interlocks are disabled, replace with type 991 tube with the exception of I 610 in the indicator. Replace I 610 with a type NE–51 lamp (par. 3*a*).
	12	Power supply	Check readings on VOLTMETER M401 and LINE FREQUENCY meter M403.	VOLTMETER M401 reads 115 volts ac ±5 volts. LINE FREQUENCY meter M403 reads from 384 to 416 cps.	Check applicable power unit literature. If the line voltage continues to exceed or remains close to the maximum voltage requirement of the radar set after obtaining an output of 400 cycles from Gasoline Engine Generator Set PU–107/U, connect Fixed Power Transformer Autotransformer TF–223/G as instructed in paragraph 7*g*. If already connected, check connections.
START	13	Indicator and receiver transmitter.	Check warmup period by pressing the RADIATE ON button (indicator) at intervals of approximately 30 seconds while observing the MAGNETRON CURRENT meter on the receiver-transmitter.	The needle on the MAGNETRON CURRENT meter will rise when the RADIATE ON button is pressed approximately 5 minutes after placing the POWER switch in the ON position. Expiration of the warmup period is also indicated by the emission of a sharp click from the receiver-transmitter. See paragraph 7*d* for exceptions of the normal 5-minute warmup period.	Adjust the time duration of timing relay K401 as instructed in paragraph 7*d*.
	14	Receiver-transmitter.	After pressing the RADIATE ON button after the expiration of the warmup period, check reading on the MAGNETRON CURRENT meter with the TRIGGER switch on the modulator in both positions. Return the TRIGGER switch to EXTERNAL.	40–44 ma steady reading.	Refer to paragraph 27. ***Caution:*** Do not continue transmitting if this reading exceeds 46 ma. ***Warning:*** Dangerous high voltages are used in the receiver-transmitter and modulator. Deenergize the equipment before removing or replacing tubes.
	15	Receiver-transmitter.	Check the MAG. FIL. reading on the test meter above the TEST SELECTOR switch.	Red line to 65 percent of full scale deflection.	Higher echelon maintenance is required.
	16	Indicator	Check for sweeps. When the remote ppi is being used, check for a sweep on its scope.	Sweeps should be present on scopes.	If only the spots of light are present on both scopes with the INTENSITY controls turned up, check cable W9 (fig. 52, TM 11–1167–10) between the receiver-transmitter and the power

START					supply for continuity with the equipment deenergized. Check V604 by substitution. If the sweep is missing on only the A scope, check wave form at TP609 (figs. 21 and 24). If the proper waveform is not present, check V604 and V622 by substitution. If the proper waveform is present, check V623 and V624 by substitution. If the A RANGE SELECTOR switch is in the EXP position, also check V621. Indication of proper functioning of V621, may be obtained by observing proper waveform at TP604 (figs. 21 and 24). If the sweep is missing on only the ppi scope, check waveform at TP601 (figs. 21 and 24). If the proper waveform is not present, check V603 and V604 by substitution. If the proper waveform is present, check V605, V606, V607, and V608 by substitution. If the sweep is missing on only the remote ppi (see fig. 50, TM 11–1167–10), if used, check for removal of jumper between R446 and R448 on the resistor panel behind the access door on the lower right side of the power supply (fig. 49, TM 11–1167–10).
EQUIPMENT PERFORMANCE	17	Indicator	Check the A-scope operating adjustments with the A RANGE SELECTOR set to 160.	The INTENSITY control (A scope) should adjust for desired illumination. The FOCUS control (A scope) should adjust for sharp detail. The VIDEO GAIN control (A scope) should adjust for a signal height of approximately 1 inch.	If a fine clear sweep cannot be obtained, adjust the ASTIG control behind the CALIBRATION CONTROLS panel for sharp focusing. Check the +300-volt supply (par. 29). Check the indicator high voltage at TP611 (step 11 above). If no video signals are present, see step 23 below.
	18	Indicator	Check the ppi-scope operating adjustments with the PPI RANGE SELECTOR set to 160 and the antenna rotating at a slow rate of speed. See step 21 below for antenna rotation check.	With the VIDEO GAIN control (ppi) initially adjusted fully ccw, the INTENSITY control (ppi) adjusted for a trace or sweep that is just visible, and the RECEIVER GAIN control	If the INTENSITY control cannot be adjusted for the desired illumination or if it is near either the extreme cw or ccw position when adjusted for the desired illumination, adjust the coarse

Phase	Step	Unit	Action	Normal indication	Corrective measures
	18			adjusted for a grass level of ¼ inch as indicated on the A scope; the VIDEO GAIN control should adjust for a sparkling trace and a slightly milky background. The FOCUS control should adjust for sharp detail.	INTENSITY control R660 (fig. 25). Check the +300-volt supply (par. 29). Check the indicator high voltage at TP612 (step 11 above). If the FOCUS control cannot be adjusted for sharp detail, check the +450-volt supply (par. 29). Check V610 by substitution. If the RECEIVER GAIN control cannot be adjusted for the proper height of grass (noise) on the A scope or if no video signals are present, see step 23 below.
EQUIPMENT PERFORMANCE	19	Indicator	Check the fixed range markers on both the A and ppi scopes by turning the RANGE MARKS MILES switch to ON and switching the A and PPI RANGE SELECTOR switches through all their positions. Check the spacing of the 25-mile markers in the 160-mile position of the RANGE SELECTOR switches with the RANGE MARKS MILES switch held in the TEST position. Also check the position and length of the sweeps on the scopes.	Range markers should be steady and the following markers of sufficient intensity should be present. 20-mile range—four 5-mile range markers. 40-mile range—eight 5-mile range markers. 80-mile range—three 25-mile range markers. 160-mile range— six 25-mile range markers. EXP range (A scope only) two 5-mile range markers. In the 160-mile or 80-mile position of the RANGE SELECTOR switches, four 5-mile markers should appear between the 25-mile markers when the RANGE MARKS MILES switch is held in the TEST position. The A-scope sweep should be positioned across the center of the scope and should almost touch the edge of the scope at both extremities. The ppi-scope sweep should be positioned with the zero-range end at the center of the screen and the opposite end almost touching the edge of the scope for all points in azimuth.	If only the 25-mile markers are missing on both scopes, check V617 and V618 by substitution. If no markers are present on both scopes, check square wave at TP605 (figs. 25 and 21). If the proper waveform is present, check V615 through V618 by substitution. If the markers are missing on only the A scope, check V612, V619, and V620 by substitution. If the markers are missing on only the ppi scope, adjust the 5–10 MILE and 25–10 MILE MARKER INT. controls behind the CALIBRATION CONTROLS panel for markers of the desired intensity. Check V602 by substitution. If the markers on the A scope are not perpendicular to the base line, adjust C659 on panel E (fig. 23), with a fiber screwdriver and with the VIDEO GAIN control (A scope) turned fully ccw, for perpendicular markers. If the 25-mile markers are blurred or erratic, or if the spacing of the 25-mile markers is not correct in the 160-mile position of the RANGE SELEC-

				TOR switches, adjust the BO. ADJ. R1618 (fig. 25) while holding the RANGE MARKS MILES switch in the TEST position. If the correct number of markers does not appear on both scopes in the 160-mile position of the RANGE SELECTOR switches, adjust the MARKER GATE control behind the CALIBRATION CONTROLS panel for a gate width just sufficient to include the 160-mile marker. When making this adjustment, it may be necessary to make slight adjustments of the A and PPI GATE controls (fig. 24). Adjust both the A and PPI GATE controls for a sweep which represents slightly more than 160 miles. If it is suspected that the spacing of the 5-mile markers is not correct, higher echelon maintenance is required. The space between each pair of 5-mile markers should represent 5 nautical miles (10,000 yards). If the A-scope sweep is not centered properly, adjust the HORIZ CENTER and VERT CENTER controls behind the CALIBRATION CONTROLS panel. If the ppi-scope sweep is not centered properly, adjust the PPI CENTERING controls behind the CALIBRATION CONTROLS panel. If necessary, adjust the A SCOPE SWEEP LENGTH and the PPI SWEEP LENGTH controls.
	20	Indicator	Check the range strobe (movable marker) on the ppi scope with the RANGE MARKS MILES switch held in the TEST position and the PPI RANGE SELECTOR switch in the 160-mile position while turning the RANGE STROBE control from the fully ccw position to the fully cw position. Also, place the A RANGE	The range strobe should appear on the ppi scope as a clearly visible spot of light and its travel distance should be from approximately 15 miles to 150 miles. As the RANGE STROBE control is turned, the fixed markers on the A scope will move across the face of the scope and it should be possible to display any 10-mile portion of the	If there is no range strobe on the ppi scope or if it is not clearly visible, adjust the STROBE INT. control behind the CALIBRATION CONTROLS panel. Check V613, V621, and V601 by substitution. If the range strobe does not coincide with the 150-mile fixed marker on the ppi scope when the RANGE STROBE

Phase	Step	Unit	Action	Normal indication	Corrective measures
	20		SELECTOR switch in the EXP position.	received signals from approximately 15 miles to 160 miles on the A scope. The range strobe on the ppi scope should indicate the minimum range of the 10-mile expanded sweep on the A scope.	control is in its fully clockwise position, adjust the STROBE LIM control behind the CALIBRATION CONTROLS panel for coincidence of the range strobe and the 150-mile marker.
	21	Indicator	Check the antenna and ppi-sweep rotation by turning the ANTENNA ROTATE control both cw and ccw through its entire range. When the remote ppi is being used, check the sweep rotation on its scope.	The antenna should rotate smoothly in both cw and ccw directions at speeds up to 15 rpm. The speed of rotation should be as indicated on the ANTENNA SPEED dial. The sweep on the ppi scope should rotate smoothly in synchronism with the antenna.	If the antenna does not rotate, make sure that the safety switch on the antenna base is well seated in the ON position. The servo amplifier front panel must be well seated. Check contacts of K701 through K703 and K705, and clean if necessary (par. 21*a*). Check V701 through V706 by substitution (par. 31). ***Warning:*** Deenergize the equipment before removing or replacing tubes and examining relays. Screwdriver adjustments inside the servo amplifier may be adjusted only under the supervision of higher echelon maintenance personnel. If the ppi sweep does not rotate, check contacts of K704 and clean if necessary (par. 21*a*). Check the brushes and slip rings on synchros B602 and B752, and the deflection coil (L601) assembly. Clean if necessary (par. 21*b*). When the remote ppi is being used, if its sweep does not rotate, check brushes and slip rings on B753. If the antenna rotates at only a very slow speed (approximately 1 rpm or less) and if the speed cannot be increased by turning the ANTENNA ROTATE control to a higher speed setting; turn the ANTENNA ROTATE control back to 0 RPM, wait 4 to 5 seconds, then advance the ANTENNA ROTATE control. If the speed of rotation of the antenna and ppi sweep is not correct, adjust the ANTENNA SPEED control

				R2619 in the top side of the indicator (pars. 12*c* and 31). If the ppi sweep does not follow the antenna rotation smoothly or if the antenna does not rotate smoothly, need for synchro and servo amplifier alinement is indicated.
22	Receiver-transmitter.	Check the SIG. and COHO crystal current reading on the test meter above the TEST SELECTOR switch.	SIG. current: red line COHO current: red line	If both readings are zero or very low, check the voltage across test points TP501 and TP502 (fig. 33). This reading should be between 5.7 and 6.7 volts dc. If no voltage reading is present between TP501 and TP502, check ballast tube TY501 by substitution. If the reading between TP501 and TP502 is low, check local oscillator tube V505 by substitution (par. 35). Check the —150-volt supply at terminal 7A on E401 (par. 29), and check V505 by substitution if it has not been previously checked. If only the SIG. reading is zero or low, check the signal mixer-local oscillator coupling (par. 13*i*). Check the signal mixer crystal by substitution (par. 38*a*). Check cables W504, W503, W502, and the signal crystal current test cable (fig. 34) for continuity. Check for tight fitting cap E506 (fig. 34) on V504 and check V501. If only the COHO reading is zero or low, check the coho mixer-local oscillator coupling (par. 14*b*). Check coho mixer crystal CR502 by substitution (par. 38*b*). Check cables W501 and W507 (fig. 34) for continuity. If either the SIG. or COHO reading is high, reduce the mixer-local oscillator coupling.
23	Indicator	With the OPERATION SELECTOR switch on the signal comparator in the REMOTE position, the OPERATION switch on the indicator in the NORM position, and the echo box connected and tuned to the radar set; check the normal signals and ringtime	Good clear video signals should be present on the scopes and approximately ¼ inch of grass should be present on the A scope when the OPERATION switch is in the NORM position. A ringtime of approximately 12 miles should be obtained with the MAG-	If no signals (normal and mti) are present on the A scope only, readjust the A-scope VIDEO GAIN control. Check V619 by substitution. *Note.* Defective tubes V612 and V620 can also cause a loss of all signals on the A scope, but the fixed range markers will be affected too (step 19 above).

Phase	Step	Unit	Action	Normal indication	Corrective measures
	23		on the scopes (figs. 60, 61, and 67, TM 11–1167–10). (See paragraph 13 for echo box operating instructions.) With the operation switch in the MTI position, check the mti signals, (figs. 60 and 61, TM 11–1167–10). When the remote ppi is being used, check the signal on its scope.	NETRON TUNING knob on the receiver-transmitter tuned to 1,280 mc, as measured with the echo box. Signals from moving targets and a minimum amount of ground clutter should appear on the scope when the OPERATION switch is in the MTI position. When the controls are set for normal operation, ringtime and wide pulses on the scopes should be differentiated when the ANTI-JAM switch is placed in the ON position.	If no signals (normal and mti) are present on the ppi scope only, readjust the ppi scope VIDEO GAIN control. *Note.* A defective tube V602 can also cause a loss of signals (normal and mti) on the ppi scope, but the fixed range markers will be affected too (step 19 above). If only mti signals are present on both scopes, check V3306 by substitution. Also, check contacts of K3300 and K3301. If weak normal signals and low ringtime are present on both scopes, perform the normal receiver alinement procedures (par. 13). If the normal alinement fails to correct the low ringtime and poor signal condition, check the reading on the TEST METER on the signal comparator with the TEST SELECTOR switch in the I. F. AMPL. LEVEL position. If a low reading is obtained on the TEST METER, check V301 through V306, V224, V225, and V232 by substitution. If approximately a red-line reading is obtained, check V3307, V611, and V612 by substitution. Also check tr tubes V503 and V504 by substitution. If no signals (normal and mti) are present on both scopes, check the reading on the TEST METER with the TEST SELECTOR switch in the I. F. AMPL. LEVEL position. If no reading or a low reading is obtained on the TEST METER, check V301 through V306, V224, V225, and V232 by substitution. Also check cable W5 (fig. 52, TM 11–1167–10), between the signal comparator and the receiver-transmitter, and the signal if preamplifier output cable (fig. 34) for continuity. If approximately a red-

				line reading is obtained, check V3307, V611, and V612 by substitution. Also check cable W14 (fig. 52, TM 11–1167–10) between the signal comparator and the power supply for continuity. If the loss of normal and mti signals continues, check tr tubes V503 and V504 by substitution, and check connections to terminal board E553 which is mounted next to relay K501 (fig. 34). Check contacts of K3300 (fig. 22). Perform the normal alinement procedure (par. 13). *Note.* If it is observed that no reading or low reading is present on the TEST METER, but signals are present on the scopes, check V307 by substitution. If a large amount of clutter appears on the scopes when the OPERATION switch is in the MTI position, adjust the MTI BALANCE and AMPL. BALANCE controls for a minimum amount of clutter. If these adjustments fail to reduce the clutter, refer to paragraph 28. If only normal signals are present on both scopes, refer to paragraph 28. If normal signals are present, but ringtime is not present and there is no meter reading on the echo box for all positions of its tuning knob, check the directional coupler cable (fig. 34) for continuity. When a remote ppi is being used, if signals are absent from the remote ppi scope, check for signals at TP301 on the front of the signal comparator. If no video is present, check V3308 by substitution. If video is present, check cable W13 (fig. 52, TM 11–1167–10) between the signal comparator and power supply for continuity.
	24	Indicator	Rotate the antenna during normal operation until a target of known azimuth is in the antenna line-of-sight axis and appears as a bright spot on the	The ppi sweep should point to the reading on the ppi azimuth dial corresponding to the known azimuth of the target (fig. 59, TM 11–1167–10). Adjust the AZIMUTH control on the front of the indicator as explained in paragraph 15. If it is impossible to obtain proper illumination of the azimuth dial, check

Phase	Step	Unit	Action	Normal indication	Corrective measures
EQUIPMENT PERFORMANCE	24		ppi sweep (par. 15). Check the position of the sweep on the ppi scope.	just the DIMMER control to illuminate the azimuth dial as required.	the ppi scale lights (fig. 23) and replace any lights that are not illuminated with type No. 47 lamps.
	25	Summation bridge and uhf signal generator.	Make the performance tests outlined in paragraph 16.	The peak transmitter output power should be not less than 86.5 dbm. The minimum discernible signal should be between —102.3 and —104.0 dbm.	High echelon maintenance is required.
STOP	26	Indicator_____	Set the ANTENNA ROTATE control to obtain 0 RPM indication on the ANTENNA SPEED dial. Press the RADIATE OFF button. Set the POWER switch to OFF. Stop the power unit, following instructions in applicable literature.	The antenna stops rotating when the ANTENNA ROTATE control is set to 0 RPM on the ANTENNA SPEED dial. No drifting is observed. The reading on the MAGNETRON CURRENT meter drops to zero and the sweeps on the scopes disappear when the RADIATE OFF button is pressed. The power-on indicator above the POWER switch goes out and the blowers stop operating when the POWER switch is set to OFF. The power unit stops and the readings on VOLTMETER M401 and LINE FREQUENCY meter M403 disappear when the power unit stopping procedure is performed.	

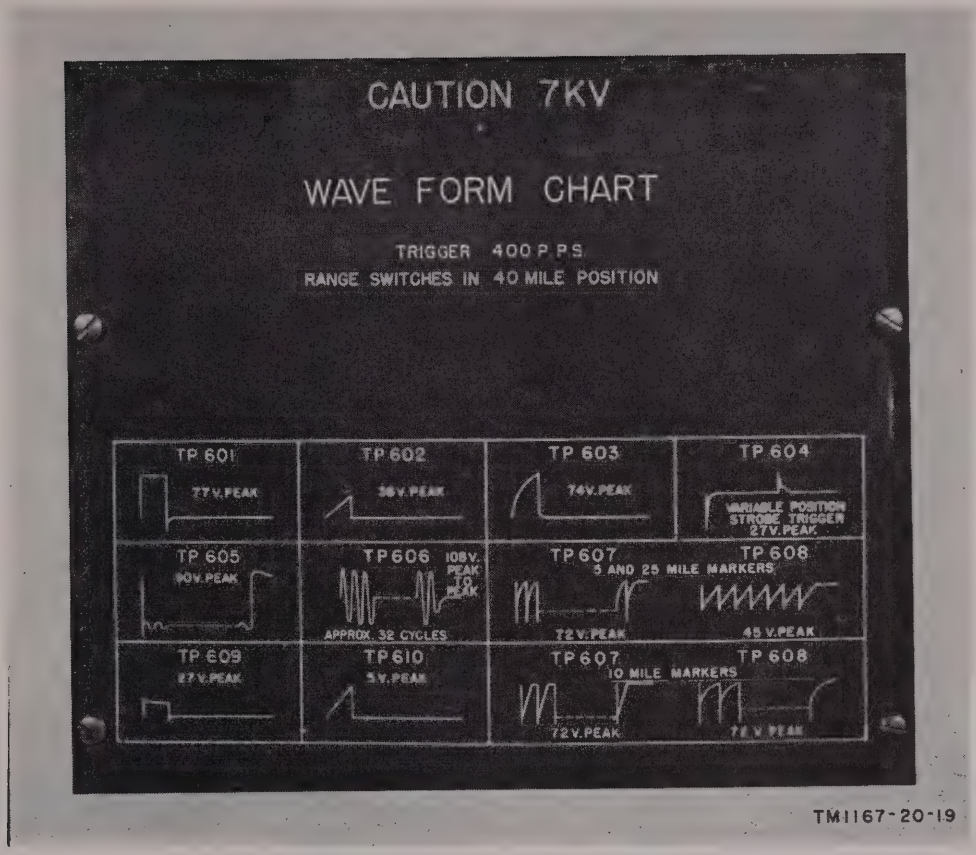


Figure 21. Indicator waveform chart.

27. Equipment Performance Checklist, Step 14, Supplementary Information

a. Magnetron Current Abnormal During External Trigger Operation Only. Place the TRIGGER switch on the modulator in the INTERNAL position. If a normal magnetron current indication is obtained in this position but an abnormal indication is obtained when the TRIGGER switch is returned to the EXTERNAL position, proceed as follows:

(1) Check adjustment of the carrier gate length control R1365 (pars. 8*a*(1) (*b*) and 14*f*).

(2) Check cable W3 (fig. 52, TM 11–1167–10) between the signal comparator and the modulator for continuity with the multimeter when no magnetron current indication is obtained. Also check V1352 through V1354 (fig. 30) by substitution.

Note. Before disconnecting cables for continuity check, turn off power.

(3) Check the +150-volt supply. Also check the —150-volt supply at terminal 6A on E401 (par. 29).

(4) If the magnetron current is slightly low, check the signal comparator internal cabling (fig. 22) for connection to proper positions. Also check V1355 through V1357, V1301 through V1306, V1350 through V1351, V2301 through V2306, and V3300 through V3302 by substitution. If the magnetron current remains low, check the signal comparator for correct TEST METER readings with the TEST SELECTOR switch in positions (3) through (5) and in accordance with TEST INSTRUCTIONS on the front panel of the signal comparator. See paragraph 28*a* for detailed troubleshooting procedures to be followed when abnormal TEST METER readings are obtained. If the readings obtained in positions (3) and (4) of the TEST SELECTOR

switch are correct but there is no AMPL. BALANCE reading or a low AMPL. BALANCE reading, which cannot be brought up to a red-line indication, check the attenuation of the delay line as outlined below.

(*a*) Pull the signal comparator chassis out to the stopped position, release the chassis catches (par. 6*c*(1)), pull the chassis out further until it is barely clear of its housing, and turn it on its side to expose connections on the delay line (fig. 22).

Caution: There is danger of straining or breaking the cables which connect the signal comparator to its delay line. Do not pull the chassis out farther than directed above.

(*b*) Disconnect P2351 on the delay line output cable from J2351, and disconnect P2350 on the delay line input cable from J2350 (fig. 22).

(*c*) Connect the test attenuator Z2350, which is mounted on fuse clips in the rear of the top side of the signal comparator (fig. 30), between P2351 and P2350 on the disconnected cables.

Note. This connection substitutes the test attenuator for the delay line.

(*d*) If a red-line reading is now obtained or if it can be obtained by adjusting the AMPL. BALANCE control, the delay line is faulty, and replacement or repair by a higher echelon repairman is necessary.

b. Magnetron Current Abnormal During Either External or Internal Trigger Operation. Place the TRIGGER switch on the modulator in the INTERNAL position. If an abnormal

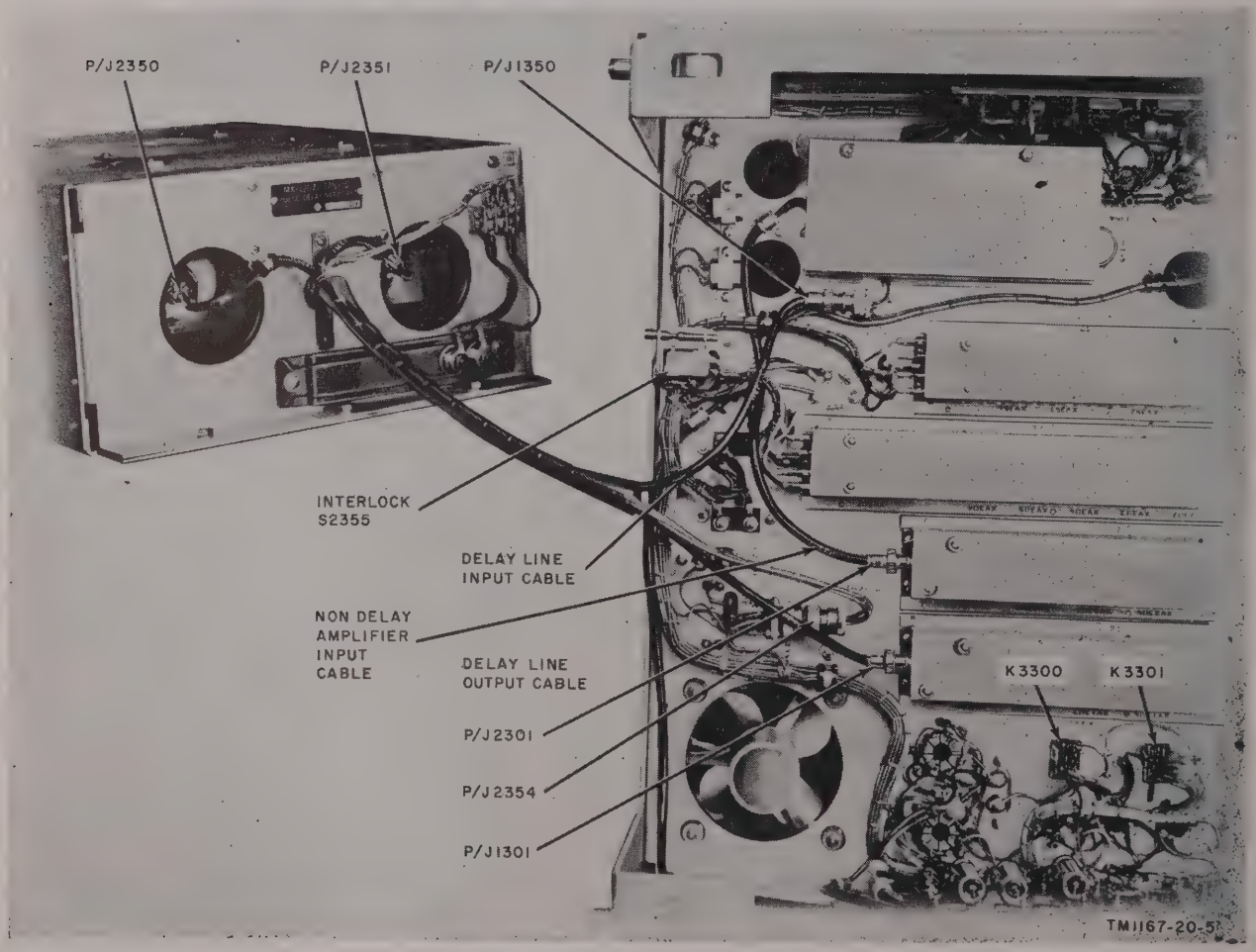


Figure 22. Signal comparator details, bottom side and delay line.

magnetron current indication is obtained in both positions of the TRIGGER switch, proceed as follows:

(1) Check thyratron keyer V156 (fig. 27) for glow. If no glow is present, proceed as outlined below. If the glow is not steady, check V156 by substitution.

(*a*) Check the heaters of V151 through V156 (fig. 27) for illumination.

(*b*) Check relay K152 (fig. 27). If closed, check contacts and clean if necessary (par. 21*a*) after removing power. If the contacts are not closed, check for movement of the small needle on the OPERATING HOURS M402 meter on the power supply. If the OPERATING HOURS M402 meter is not operating, check overtemperature switch S501 (par. 8*a*(2)(*a*)) and the 27-volt supply (par. 29).

(*c*) Press the RADIATE ON button again. If V156 glows only momentarily, check protective relay balance adjustment R168 (par. 8*a*(2)(*b*)) and listen for arcing in the RF system, indicating loose line connections (par. 20) or an improperly installed magnetron (par. 34).

(*d*) Check V151 through V156 by substitution.

(*e*) Check V102, V1101, V1102, and V103 (figs. 27 and 28) by substitution. Also, check +300-volt supply.

Note. See test point waveforms (trigger circuit), which may be checked with the oscilloscope, on the side of the trigger chassis (fig. 8) and on the block diagram (fig. 40). The output trigger from these circuits can be observed at J153 on the front of the modulator (fig. 54, TM 11–1167–10). This positive trigger at J153 should have a peak amplitude of approximately 230 volts. Physical location of test points TP101–TP104 in the trigger circuit are shown in figure 28. Loosen the trigger chassis mounting bolts (fig. 28) before attempting to pull out the trigger chassis for testing.

(2) Age the magnetron (par. 8*a*(1)(*a*)). Check the magnetron by substitution (par. 34).

(3) With the equipment deenergized, check cable W2 (fig. 52, TM 11–1167–10) between the modulator and the receiver-transmitter for continuity if no magnetron current indication is obtained.

Warning: Never disconnect this cable for a continuity or any other check when transmitting.

(4) If the magnetron current reading is steady but remains low or high, modulator high-voltage adjustment may be required (par. 8*a*(1)(*c*)).

(5) Refer to paragraph 8*a*(3) for information on adjusting the magnetron frequency when the transmitter shuts down occasionally, resulting in no reading on the MAGNETRON CURRENT meter.

c. Magnetron Current Abnormal During Internal Trigger Operation Only. If an abnormal magnetron current indication is obtained in only the INTERNAL position of the TRIGGER switch on the modulator, proceed as follows with the TRIGGER switch in the INTERNAL position.

(1) Check V101 (fig. 28) in the trigger circuit by substitution. Refer to note *b*(1)(*e*) above.

(2) Check the repetition rate adjustment (par. 39) if the magnetron current reading is low.

28. Equipment Performance Checklist, Step 23, Supplementary Information

a. Press the RADIATE OFF button on the receiver-transmitter and check all readings on the TEST METER on the front of the signal comparator with the TEST SELECTOR and OPERATION SELECTOR switches in the positions shown under TEST INSTRUCTIONS marked on the front panel of the signal comparator. If the readings are not correct, try to correct the condition by adjusting the front panel controls. Also, check the +150-volt supply. If the trouble continues, proceed as outlined below. Check each TEST METER reading in the order given, and correct any abnormal reading before proceeding.

(1) If a low reading is obtained on the TEST METER with the TEST SELECTOR switch in the I.F. AMPL. LEVEL position, refer to step 23 in

the equipment performance checklist (par. 26).

(2) If no reading or a low reading is obtained on the TEST METER with the TEST SELECTOR switch in the COHO LEVEL position, check V353 and V354 (fig. 30) by substitution. Check contacts of K3301 (fig. 22). Check cable W2353 (fig. 30) for continuity. Adjust C361 inside the signal comparator (fig. 30) for a red-line reading.

(3) If no reading or a low reading is obtained on the TEST METER with the TEST SELECTOR switch in the DELAY LINE INPUT position, check V1355 through V1357 (fig. 30) by substitution.

(4) If no reading or a low reading is obtained on the TEST METER with the TEST SELECTOR switch in the NON DELAY AMPL. OUT position, check V2301 through V2306 (fig. 30) by substitution. Check the nondelay amplifier input cable (fig. 22) for continuity.

(5) If no reading or a low reading is obtained on the TEST METER with the TEST SELECTOR switch in the AMPL. BALANCE position, check V1301 through V1306 and V3300 through V3302 (fig. 30) by substitution. Check the delay line input cable between J1350 and J2350 and the delay line output cable between J2351 and J1301 (fig. 22) for continuity. If the trouble continues, check the attenuation of the delay line (par. 27*a*(4)).

(6) If a high reading is obtained on the TEST METER with the TEST SELECTOR switch in the AMPL. BALANCE position and the AMPL. BALANCE control has no effect on this reading, check V3301 by substitution.

b. Press the RADIATE ON button on the receiver-transmitter, and place the OPERATION SELECTOR switch on the signal comparator in the MTI position. If no mti signals are obtained, check V3303 through V3305 (fig. 30) by substitution. Also, check contacts of K3300 (fig. 22). If a large amount of clutter is present on the scopes and poor signals are obtained from moving targets, complete the mti receiver alinement (par. 14). If the trouble continues, proceed as outlined below.

(1) If no locking-in action is observed on the A scope when the CORD SYNCH control is adjusted during the alinement procedures, check V350 through V352 (fig. 30) and V506 (fig. 34) by substitution. Check cable W6 (fig. 52, TM 11–1167–10) between the signal comparator and the receiver-transmitter for continuity. Also check the coho preamplifier output cable (fig. 34) for continuity.

(2) If R3306, inside the signal comparator, cannot be adjusted for approximately ¼ inch of grass on the A scope during the alinement procedure, check V3303 through V3305 by substitution.

(3) With the OPERATION SELECTOR switch on the signal comparator in the REMOTE position and the OPERATION switch on the indicator in the MTI position, if the RECEIVER AMPL. BALANCE control on the indicator cannot be adjusted for a minimum amount of clutter on the scopes during the alinement procedure, check V3300 through V3302 by substitution.

(4) If the MTI BALANCE control on the indicator cannot be adjusted for a minimum amount of clutter on the scopes during the alinement procedure, check V1350 and V1351 by substitution.

29. Equipment Performance Checklist Supplementary Information, Localization and Isolation of Trouble in Power Supply

If abnormal indications obtained during the equipment performance checks (par. 26) indicate the possibility of abnormal power supply output voltages, check the voltages under suspicion in the performance checklist *Corrective measures* column at the terminal board E401 (fig. 31) terminals listed in the table below with the multimeter (20,000 ohms per volt). Connect the multimeter common lead to ground at terminal 01 on E401 or terminal 01 on E404. Adjustment of the +150-volt and +300-volt outputs is explained in paragraph 9. If corrective measures do not restore the radar set to normal operation, higher echelon maintenance is required.

E461 terminals	Normal indication	Corrective measures
1A	+150 volts dc ±1.5 volts (+150-volt supply)	Replace tubes V401–V403, V407–V410, V406, and V413. Refer to paragraph 9 for adjustment of +150-volt output.
4A	+300 volts dc ±3.0 volts (+300-volt supply)	If +470-volt output is normal, replace tubes V414–V417, V406, and V413. Refer to paragraph 9 for adjustment of +300-volt output. If +470-volt output is abnormal, replace V404 and V405.
5A	+470 volts dc ±47.0 volts (±450-volt supply)	Replace V404 and V405.
6A	—150-volts dc ±2.0 volts (—150-volt supply)	Replace V411 and V406.
7A	—150-volts dc ±2.0 volts (—150-volt supply)	Replace V412 and V406.
8A	+28 volts dc ±2.8 volts (+27-volt supply)	Higher echelon maintenance required.

30. Fuse Replacement

All fuses are located on the power supply front panel (fig. 56, TM 11–1167–10). In addition to being marked on the front panel adjacent to the fuse, the size of each fuse is listed in the chart below. A blown-fuse indicator (type NE51 lamp) is located above each fuse. When a blown-fuse indicator is illuminated indicating a blown fuse, replace the fuse with a spare of the correct indicated size. Spare fuses of various sizes will be found in the spare fuse holders on the power supply front panel. If the fuse blows a second time, the cause must be investigated. If F401 blows while transmitting or if F416 blows while on standby operation, unplug any items such as soldering irons or trouble lights that are connected to the service (convenience) outlets (par. 3*d*). A short circuit in these items may be responsible for the blown fuse. Primarily, blower, heater, synchro, transformer, and relay circuits are fused by the remaining fuses, and higher echelon maintenance is required when trouble develops. Use the fuse puller (fig. 19), located behind the access door on the power supply front panel, for removing and replacing fuses F416 through F415.

Fuse	Fuse rating, 250 volts (amp)	Fuse	Fuse rating, 250 volts (amp)	Fuse	Fuse rating, 250 volts (amp)	Fuse	Fuse rating, 250 volts (amp)
F401	1.6	F405	1.6	F409	6.25	F413	60
F402	1.6	F406	6.25	F410	6.25	F414	30
F403	4	F407	0.15	F411	30	F415	30
F404	6.25	F408	15	F412	60	F416	6.25

31. Tube Troubleshooting Chart

Symptom	Action or condition	Additional indication	Tubes and location
Both scope tubes dark with INTENSITY controls turned up. Power-on indicator above the POWER switch illuminated.			V626 (fig. 26). *Note.* Output from +300-volt supply may be abnormal (par. 29).
No sweep on both scopes *Note.* Make certain that the RADIATE ON button on the indicator is pushed after due allowance is made for the warmup period.	Check reading on the MAGNETRON CURRENT meter on the receiver-transmitter with the TRIGGER switch on the modulator in both positions.	Normal MAGNETRON CURRENT reading (40–44 ma).	V604 (fig. 24).
		No reading on the MAGNETRON CURRENT meter with the TRIGGER switch in the EXTERNAL position.	V1352–V1354 (fig. 30).
		No reading on the MAGNETRON CURRENT meter with the TRIGGER switch in the INTERNAL position.	V101 (fig. 28).
		No reading on the MAGNETRON CURRENT meter with the TRIGGER switch in either the EXTERNAL or INTERNAL position.	V102, V103 (fig. 28); V151–V156, V1101, V1102 (fig. 27); and V502 (par. 34). *Note.* Output from +300-volt supply may be abnormal (par. 29).
Only A-scope tube dark with INTENSITY controls turned up.			V625 (par. 37).
Only ppi-scope tube dark with INTENSITY controls turned up.			V609 (par. 37).
No sweep on A scope only	Turn the A RANGE SELECTOR switch through all positions.	No sweep on the A scope in only the EXP position of the A RANGE SELECTOR switch.	V621 (fig. 24).
		No sweep on the A scope in all positions of the A RANGE SELECTOR switch.	V604, V622–V624 (figs. 24 and 26).
			V603–608 (figs. 23 and 24).
No sweep on ppi scope only			
No fixed range markers on both scopes with the RANGE MARKS MILES switch in the ON position.	Turn the RANGE SELECTOR switches through all positions.	No fixed range markers on both scopes in all positions of the RANGE SELECTOR switches.	V614–617 (fig. 25). *Note.* Output from —150-volt supply (terminal 6A on E401) may be abnormal (par. 29).
		No fixed range markers on both scopes in only the 80- and 160-mile positions of the RANGE SELECTOR switches.	V617, V618 (fig. 25).
No fixed range markers on A scope only.			V619 (fig. 23).

No movable range marker (strobe) on the ppi scope with the PPI RANGE SELECTOR switch in the 160-mile position.			V613, V621, V601 (figs. 23 and 24) (common to iff video).
Ppi scope cannot be focused			V610 (fig. 23). *Note.* Output from +450-volt supply may be abnormal (par. 29).
Antenna and ppi-scope sweep rotates at a constant speed, which is greater than the highest speed indicated on the ANTENNA SPEED dial on the indicator, in all positions of the ANTENNA ROTATE control other than 0 RPM.			V703 (fig. 29).
Antenna and ppi-scope sweep do not rotate or rotate at a lower speed than the speed indicated on the ANTENNA SPEED dial.	Turn the ANTENNA ROTATE control back to 0 RPM. Wait 4 to 5 seconds, then advance the ANTENNA ROTATE control.	Trouble continues	V701–V706 (fig. 29). *Note.* Output from +150-volt supply may be abnormal (par. 29).
No signals (echoes) on A scope only with its VIDEO GAIN control turned up.			V619 (fig. 23).
No signals and markers on A scope only.			V612, V619 (fig. 23).
No signals and markers on ppi scope only (ppi VIDEO GAIN control turned up).			V602 (fig. 23).
No signals on both scopes with controls set for normal operation. Proper signals are present when controls are set for mti operation.			V3306 (fig. 30).
No signals or weak signals on both scopes with controls set for either normal or mti operation.	Check reading on MAGNETRON CURRENT meter.	Abnormal MAGNETRON CURRENT reading.	V502 (par. 34).
	If MAGNETRON CURRENT reading is normal (40–44 ma), check the SIG and COHO crystal current readings on the test meter above the TEST SELECTOR switch on the receiver-transmitter.	Both SIG and COHO readings are zero or low.	V505 (par. 35) and TY501 (fig. 33).
		SIG reading only is zero or low	CR503 (par. 38) and V501 (fig. 32). Also, V503 and V504 (par. 36).
	If SIG and COHO crystal current readings are normal (red-line), check the I.F. AMPL. LEVEL reading on the TEST METER on the signal comparator, following the TEST INSTRUCTIONS on the front panel.	I.F. AMPL. LEVEL reading is zero or low. *Note.* If this reading is zero or low when scoped presentations are normal, check V307 (fig. 30).	V301–V306 (fig. 30), V224, V225 and V232 (fig. 34). *Note.* Outputs from +150-volt and —150-volt supplies may be abnormal (par. 29).

Symptom	Action or condition	Additional indication	Tubes and location
		I.F. AMPL. LEVEL reading is normal (red-line).	V3307 (fig. 30), V611 and V612 (fig. 23). Also, V503 and V504 (par. 36).
No mti signals, weak mti signals, or excessive clutter on both scopes with controls set for mti operation.	Check readings on the TEST METER on the signal comparator, following the TEST INSTRUCTIONS on the front panel.	I.F. AMPL. LEVEL reading is zero or low.	See symptom directly above.
		COHO LEVEL reading is zero or low.	V353 and V354 (fig. 30).
		DELAY LINE INPUT reading is zero or low.	V1355–V1537 (fig. 30).
		NON DELAY AMPL. OUT reading is zero or low.	V2301–V2306 (fig. 30).
		AMPL. BALANCE reading is zero or low.	V1301–V1306 and V3300–V3302 (fig. 30).
	TEST METER readings are normal and no mti signals are observed on the scopes.		V3303–V3305 (fig. 30).
	If the TEST METER readings are normal and excessive clutter is observed on the scopes, check the COHO crystal current reading on the test meter on the receiver-transmitter.	COHO reading is zero or low	CR502 (par. 38).
	If the COHO reading is normal (red-line) and the trouble continues, check for phase-locking, time-balancing, and amplitude-balancing of the signals.	Phase-locking action is not observed when the COHO SYNCH control on the front of this signal comparator is adjusted (par. 14*h*).	V506 (fig. 34) and V350–V352 (fig. 30).
		No cancelation of clutter is observed when the MTI BALANCE control is adjusted (par. 14*m*).	V1350 and V1351 (fig. 30).
		No cancelation of clutter is observed when the RECEIVER AMPL BALANCE control is adjusted (par. 14*m*).	V3300–V3302 (fig. 30).
No signals or weak signals on the remote ppi.			V3308 (fig. 30).

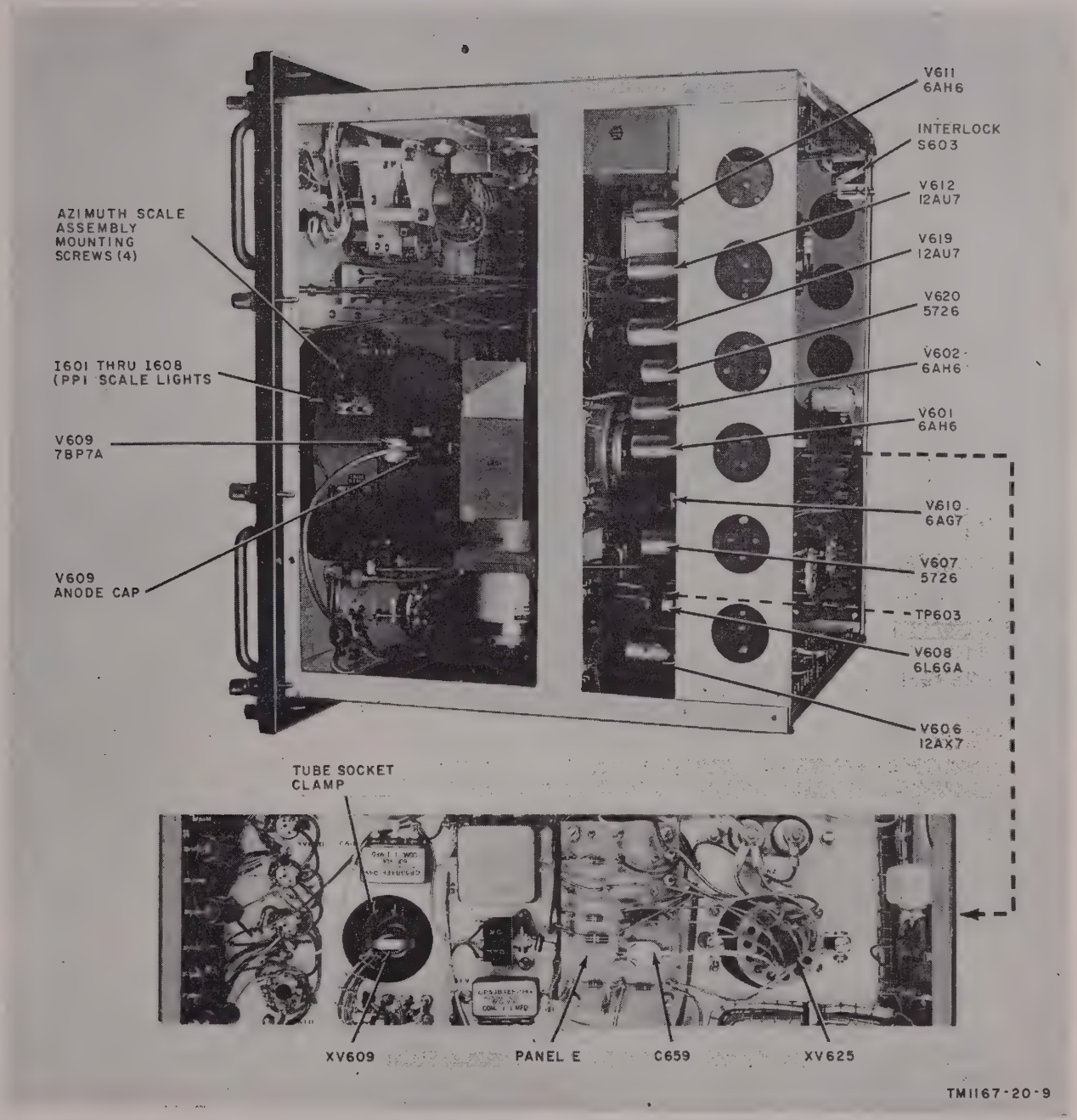


Figure 23. Indicator details, right side and rear.

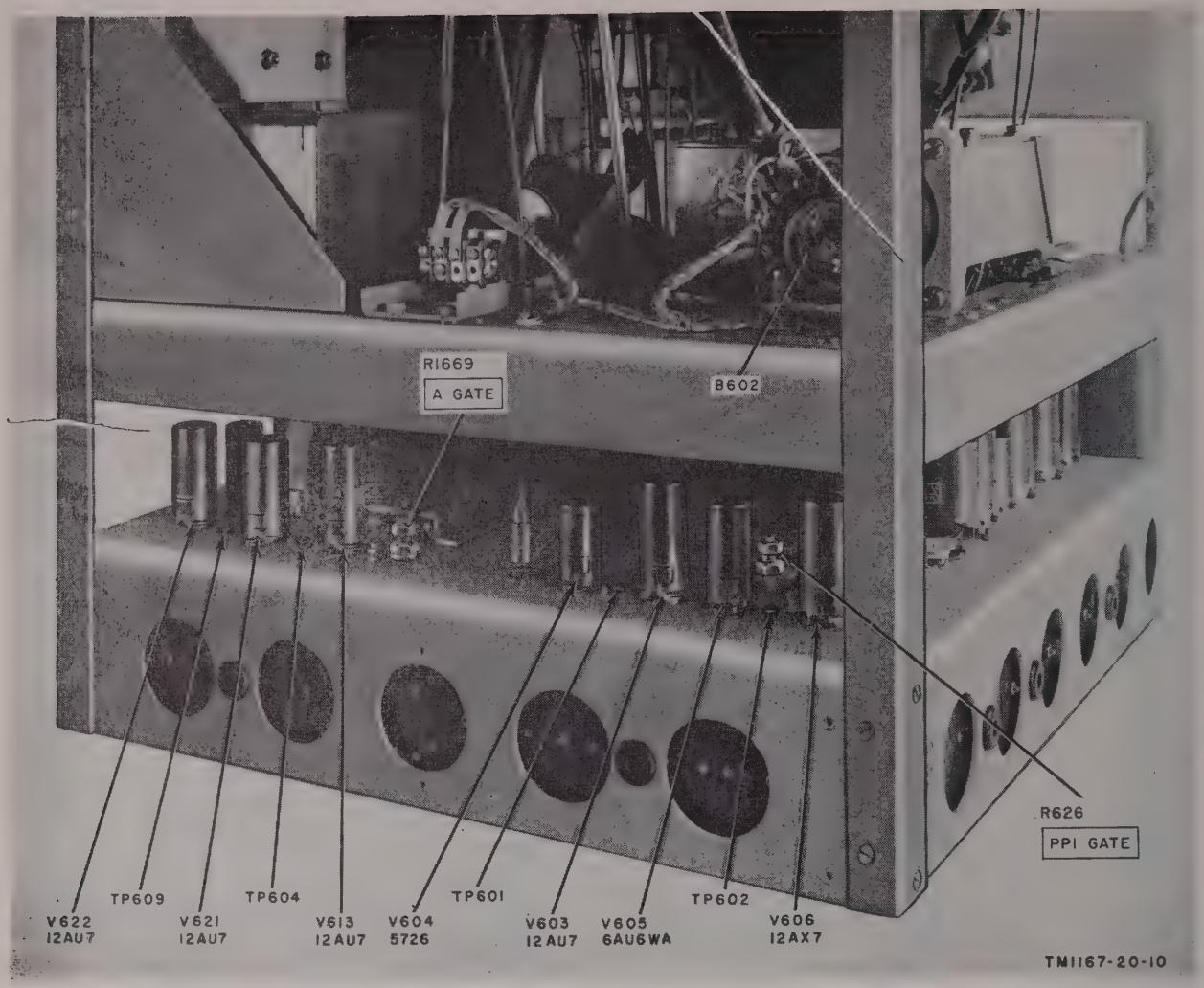


Figure 24. Indicator details, bottom side.

32. Tube Testing and Replacement

When trouble occurs, use the equipment performance checklist (par. 26) and the tube troubleshooting chart (par. 31) to locate the trouble. A single-tube substitution method for checking tubes under suspicion is outlined in *b* below. If this procedure fails to clear the trouble, continue with the procedure outlined in *c* below. If a tube tester is available, the procedure outlined in *a* below may be followed. Do not use nonpreferred-type tubes in place of preferred types. For example, do not use a 6AK5 (nonpreferred) to replace a 5654/6AK5W (preferred). Magnetron V502, local oscillator V505, tr tubes V503 and V504 and scope tubes V625 and V609 require special replacement techniques and special adjustments after replacement (par. 34–37).

Cautions:

1. Do not rock or rotate the top of a miniature tube when removing it from its socket; *pull it straight out.* Rocking or rotating the tube causes the pins to bend and may break the weld where the pins enter the glass. A high resistance or intermittent joint may develop.

2. Sockets for V151–154 in the modulator (fig. 27) and V701 and V702 in the antenna base (fig. 29) have twist-lock shells. After removing plate caps, gently press down on the tubes in the sockets, and twist counterclockwise (ccw) before pulling straight out.

3. Some type 5684/C3J/A tubes have an overall length of 6 inches or over, thereby interfering with closing the servo amplifier in the antenna base. To meet the difficulty, which may result in broken tube envelopes if not corrected, plate

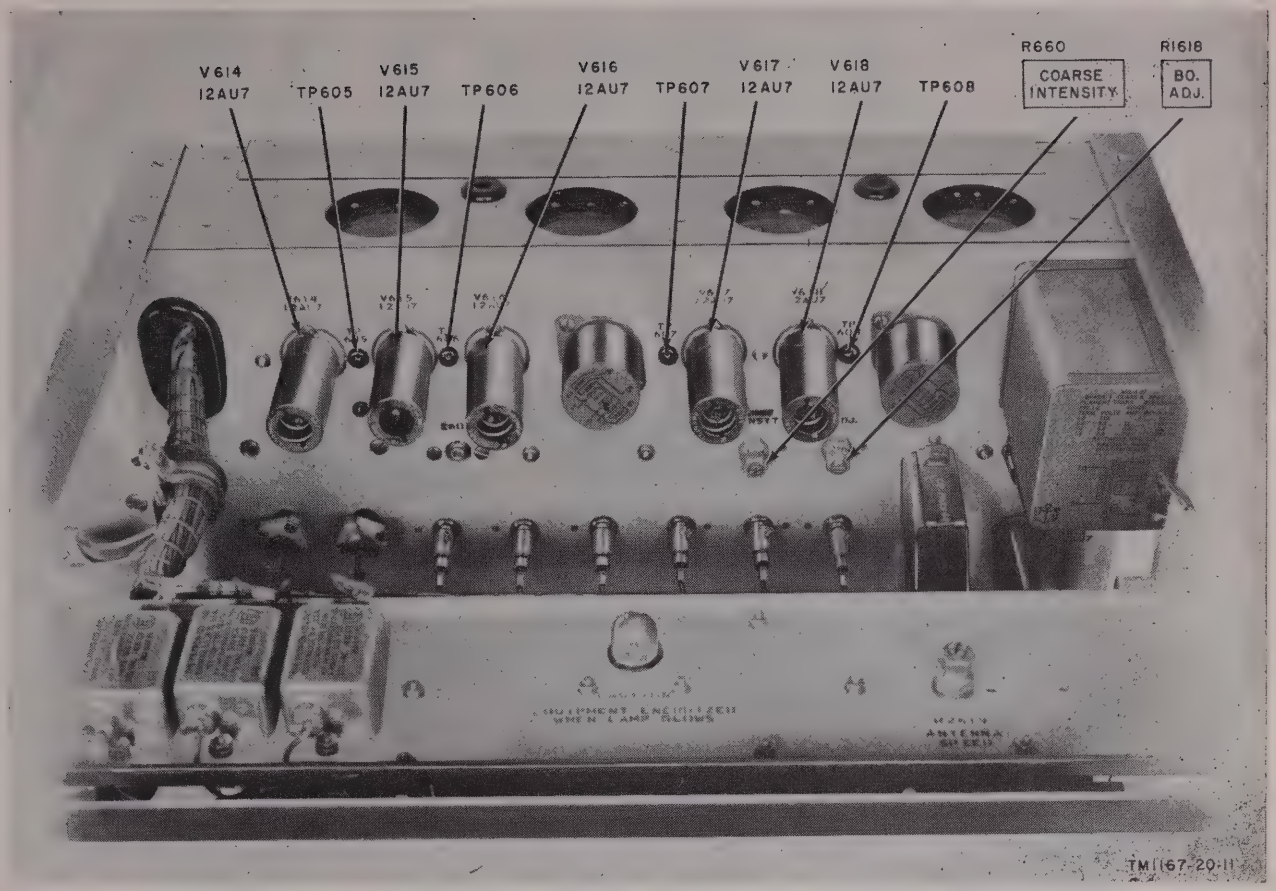


Figure 25. Indicator details, top side.

caps should be replaced with clip-type caps (Federal stock No. 5940–186–8953).

a. Using Tube Tester.

(1) Remove and test *one* tube at a time. If it is necessary to remove more than one tube at a time, label each one so that it can be replaced, if satisfactory, in its original socket.

(2) Replace a tube only when there is an obvious defect, such as a broken glass envelope, open filament, broken lead or equipment shows the tube to be defective.

(3) Do not discard a tube merely because it tests *on or near* the minimum test limit of the tube tester. Some new tubes test near the low end of the acceptable range of the tube specification. These tubes provide satisfactory service over a long period of time, even though they remain at, or near, this low limit value.

(4) Do not discard a tube merely because it has been in use for a specified length of time. *Satisfactory operation in a circuit is final proof of tube quality.*

b. Single-Tube Substitution Method.

(1) Substitute a new tube for one of the suspected original tubes. If the equipment continues to be inoperative replace the new tube with the original. Check each original tube suspected, one at a time, until the defective tube is located and the equipment becomes operative. Discard the last original tube removed from the equipment. DO NOT LEAVE A NEW TUBE IN A SOCKET IF THE EQUIPMENT OPERATES SATISFACTORILY WITH THE ORIGINAL TUBE.

(2) If this method of tube substitution does not correct the trouble, try the method described in *c* below.

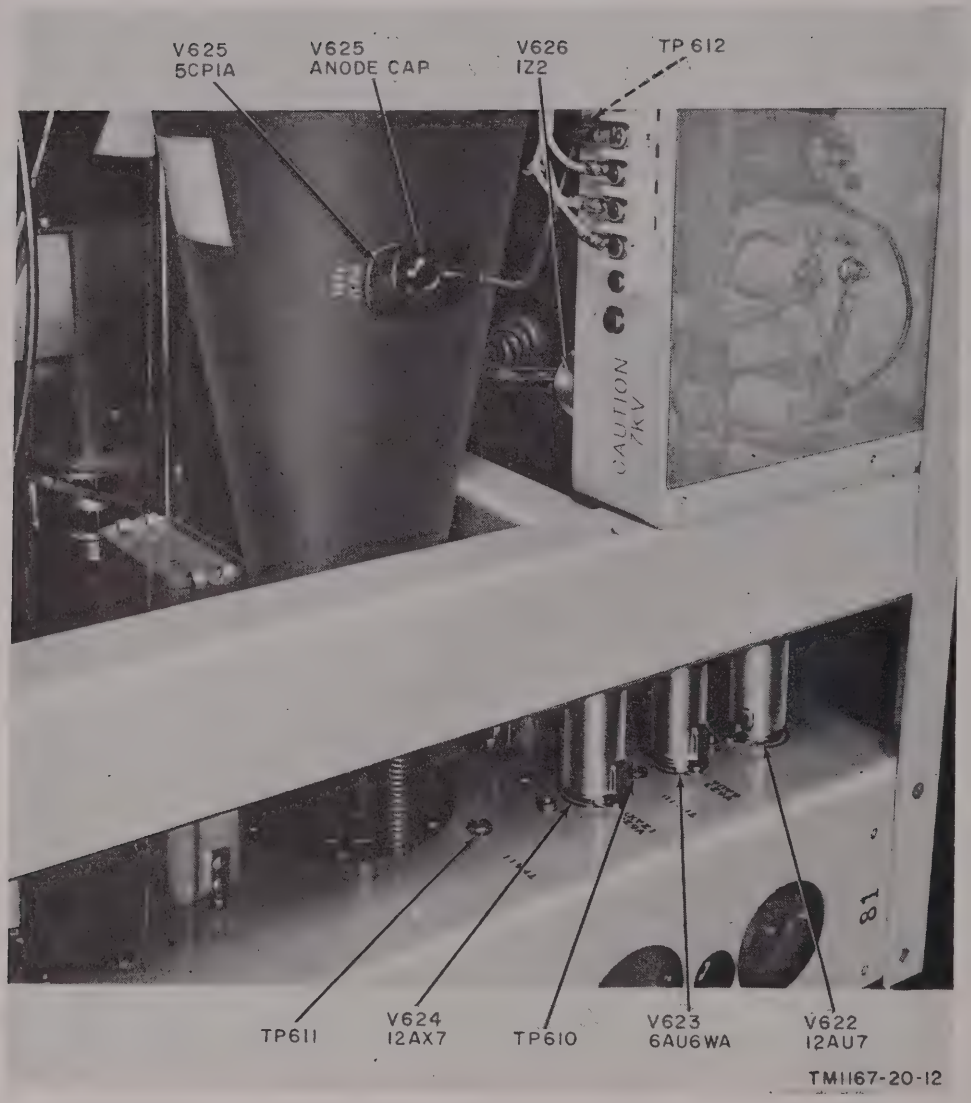


Figure 26. Indicator details, left side.

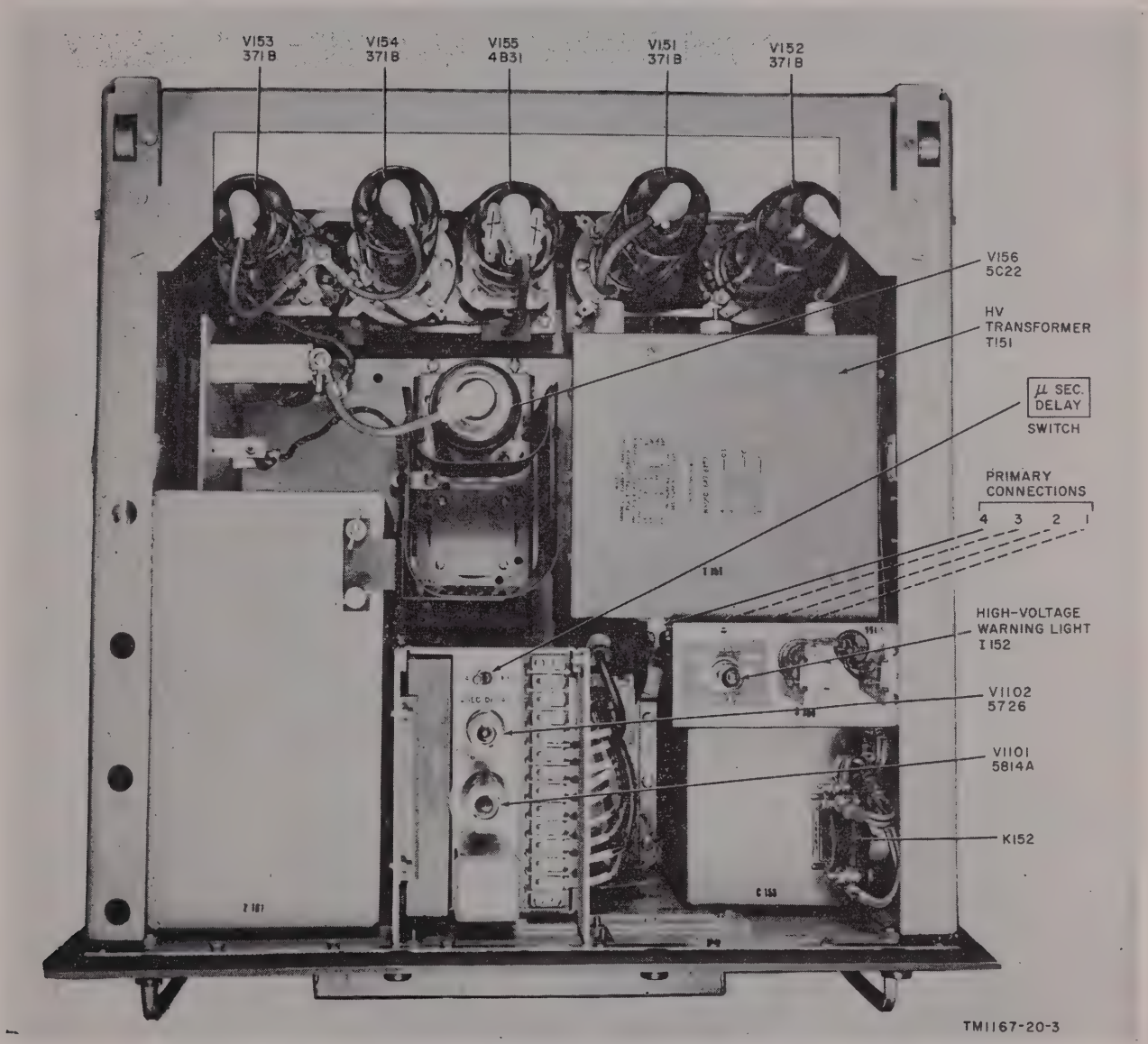


Figure 27. Modulator details, top side.

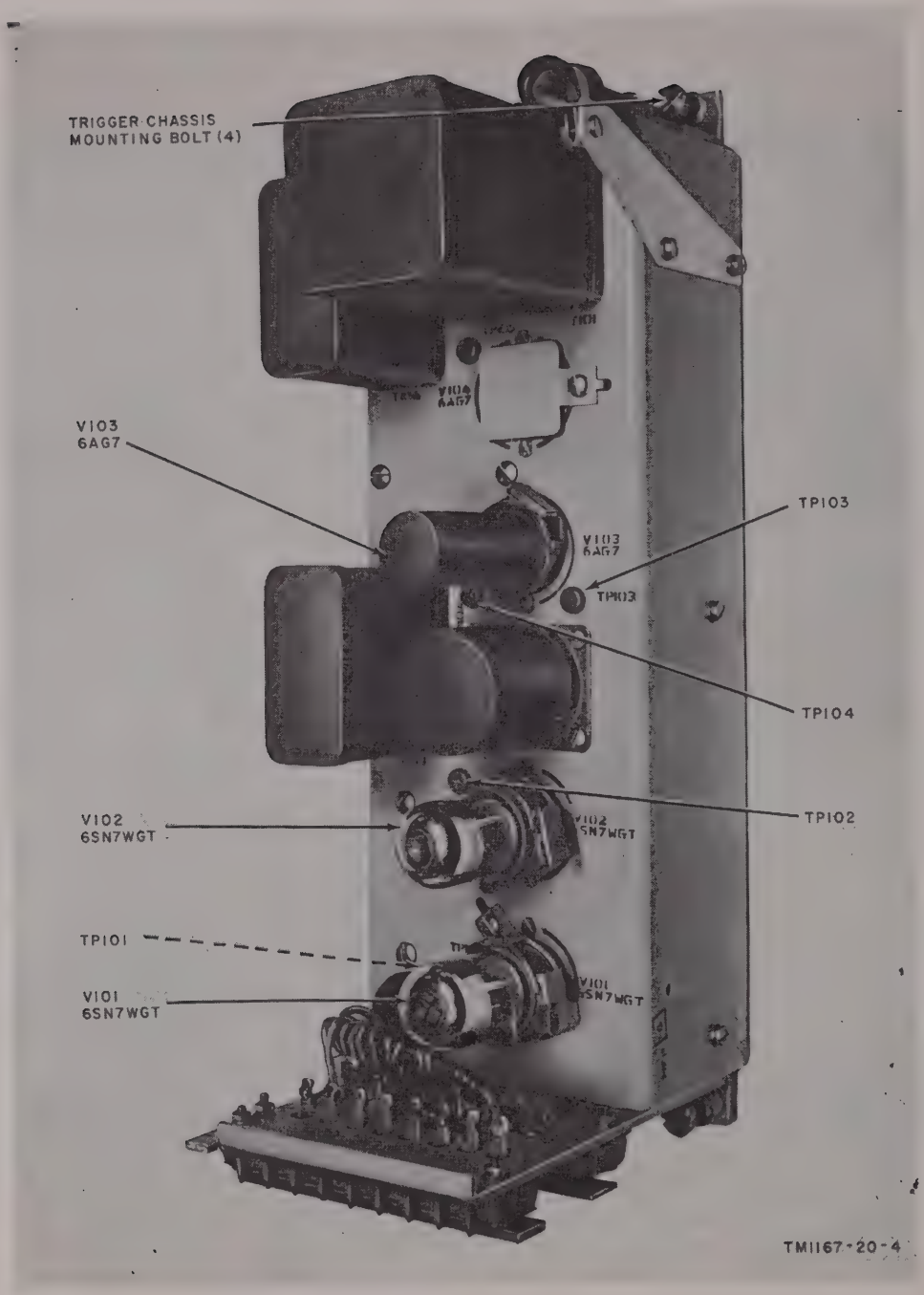


Figure 28. Modulator details, trigger chassis.

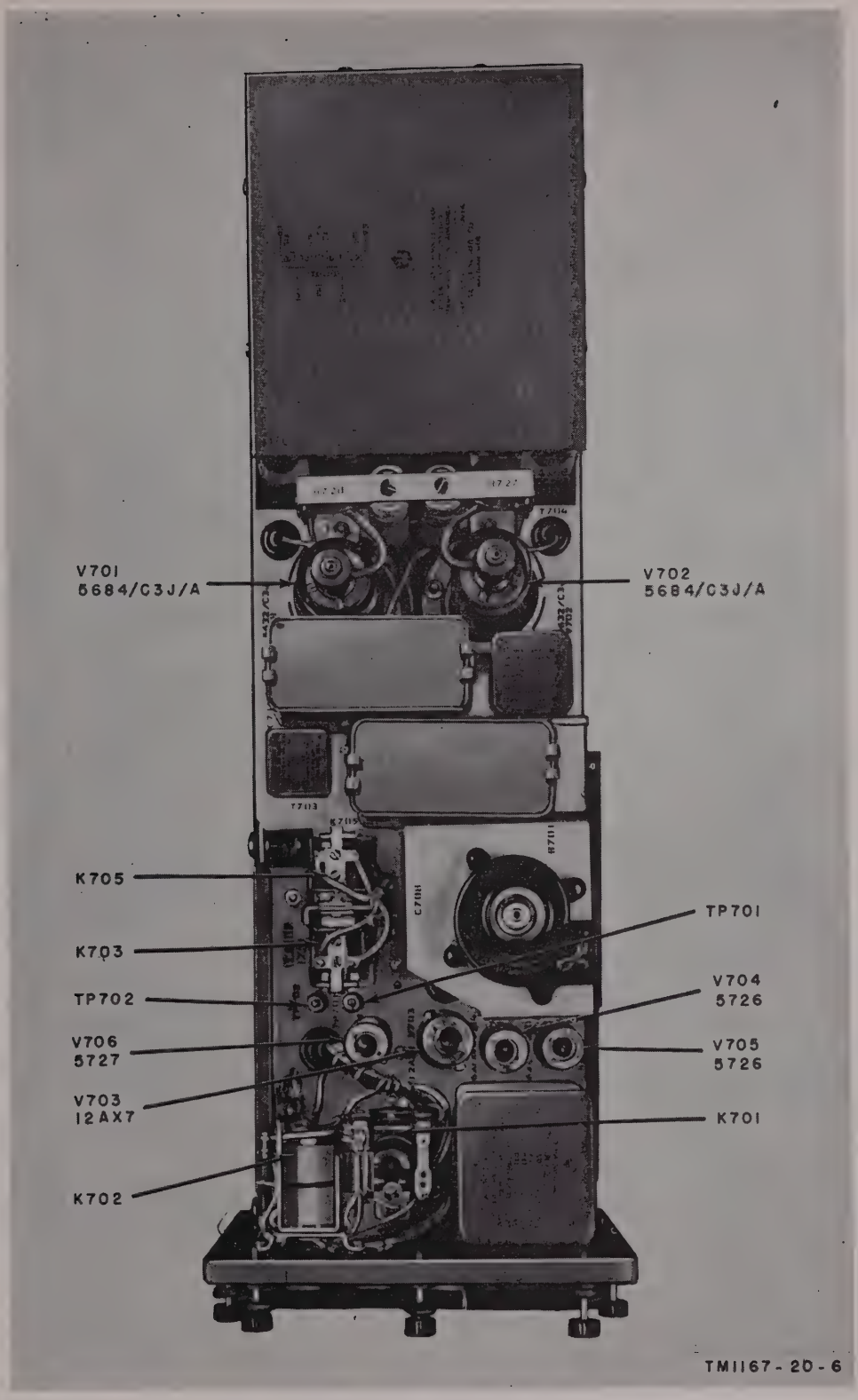


Figure 29. Servo amplifier details, top side.

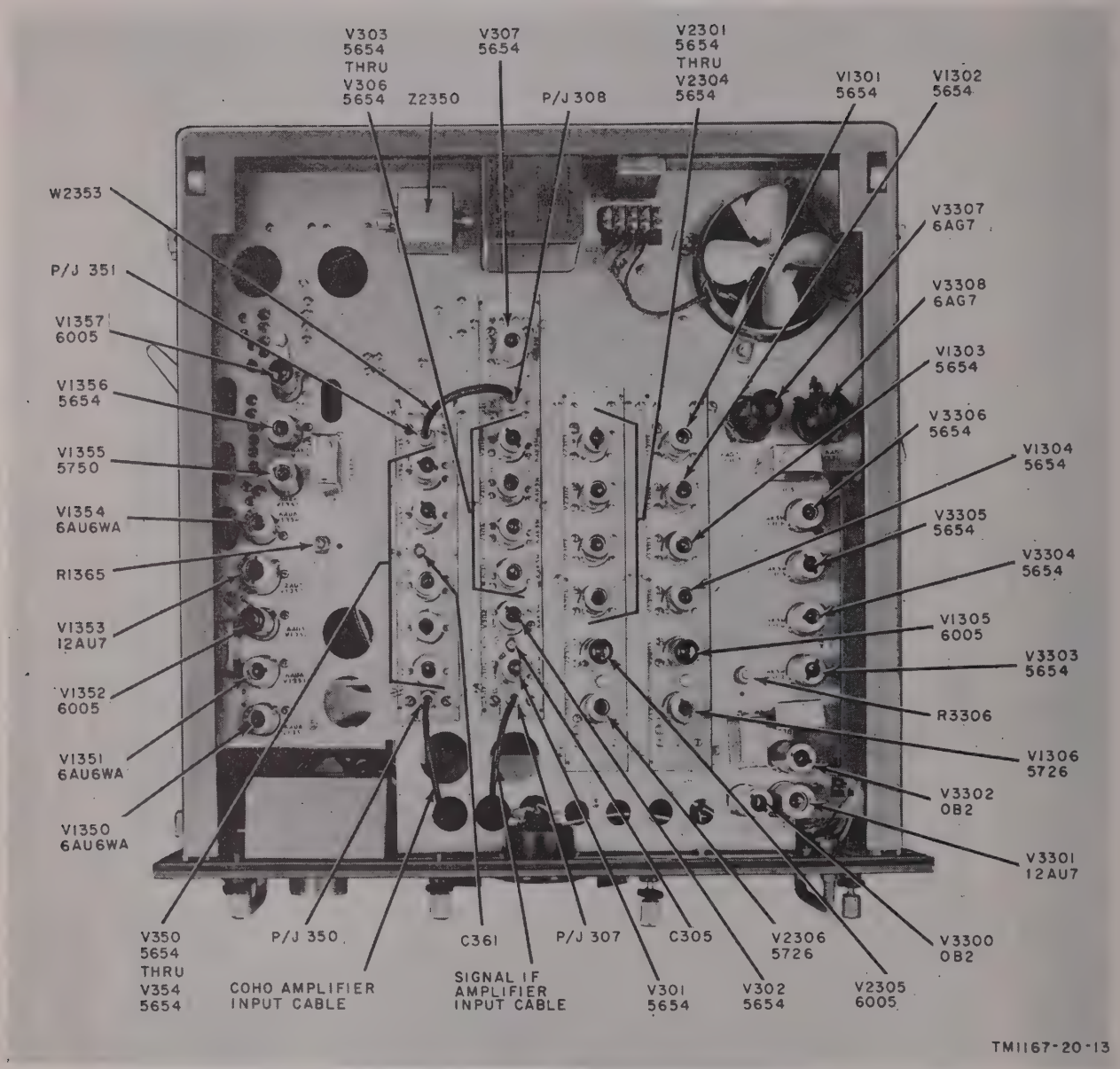


Figure 30. Signal comparator details, top side.

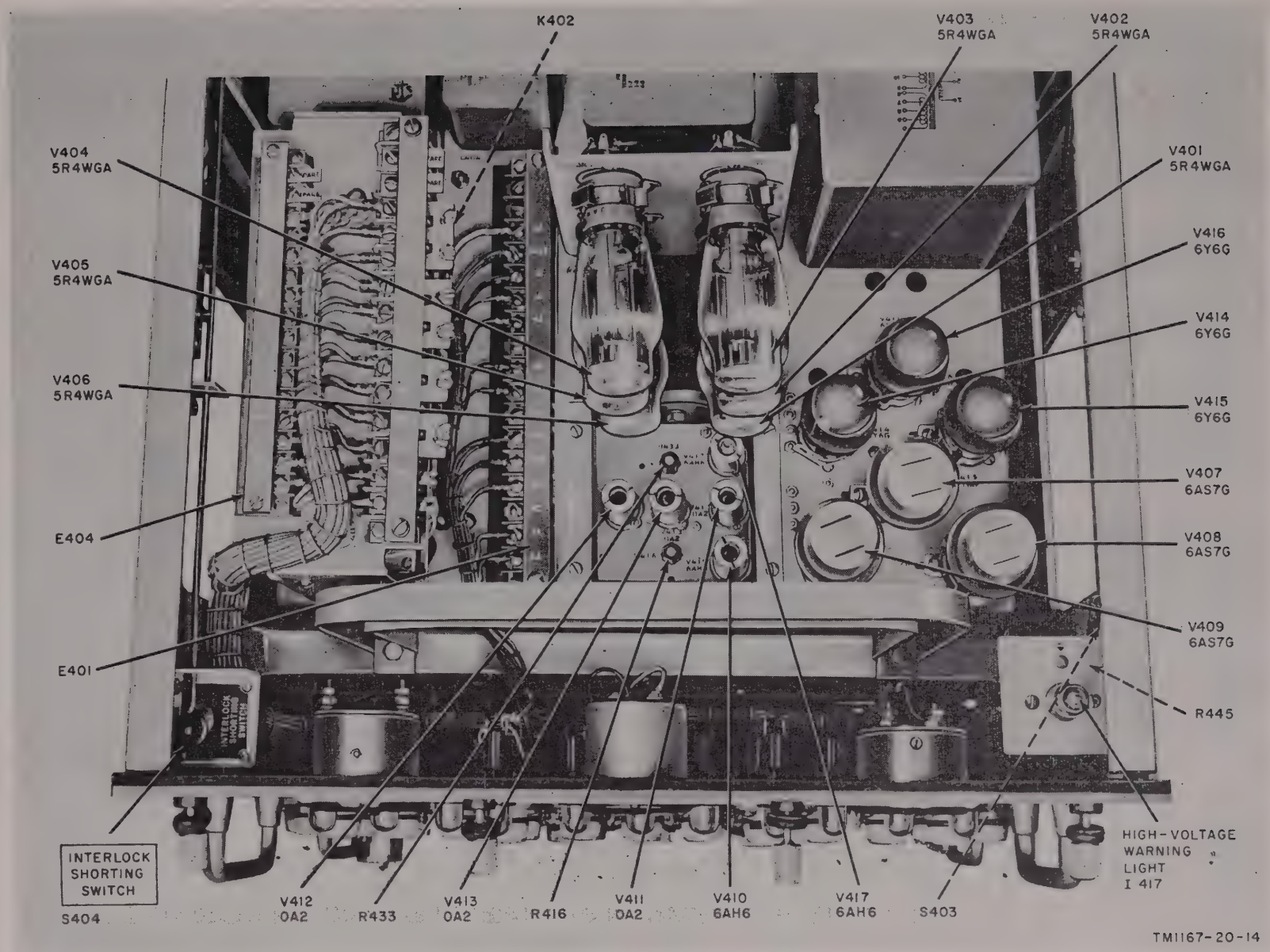


Figure 31. Power supply details, top side.

c. Multitube Substitution Method. Occasionally, two or more tubes are defective. It is then necessary to install new tubes, one at a time, until the equipment becomes operative. Proceed as follows:

(1) Remove one of the suspected original tubes. Install a new tube. If the equipment is still inoperative, leave the new tube in place and remove the next suspected tube. Mark the original tubes with the socket number from which they are removed. Continue this procedure until the equipment becomes operative. The last original tube removed is defective and should be discarded.

(2) To determine whether another original tube is defective, return one of them to its original socket. If there is no noticeable difference in performance, leave the original tube in the equipment. In the same way, return the remaining original tubes to their sockets, one at a time. If failure occurs, or performance suffers, discard the last original tube installed. DO NOT LEAVE A NEW TUBE IN A SOCKET IF THE EQUIPMENT OPERATES SATISFACTORILY WITH THE ORIGINAL TUBE.

d. Turn-In for Repair. If none of the procedures outlined above restores the equipment to normal operation, *return the original tubes to their sockets* before forwarding the defective item to a higher echelon for repair.

33. Preferred-Type Tubes

The chart below lists the authorized type tube replacements for each nonpreferred-type tube used in Radio Set AN/TPS–1D.

Nonpreferred-type tube	Preferred-type tube
2C51	5670
2D21W	5727/2D21W
5R4WGY	5R4WGA
6AG7	6AG7Y[a]
6AK5W	5654/6AK5W
6AL5W	5726/6AL5W
6AQ5	6005/6AQ5W
6AU6	6AU6WA
6BE6	5750/6BE6W
6L6GA	6L6WGB[b]
12AU7	5814A[c]

[a] 6AG7Y has a low loss base.
[b] 6L6WGB uses a different size tube clamp.
[c] 5814A is used for V1101 in the modulator (fig. 27), but a 12AU7 is used for all other stages requiring this type tube.

Section III. REPAIRS AND ADJUSTMENTS

34. Replacement of Magnetron V502 (figs. 32 and 33)

Cautions:

1. Do not wear a wristwatch when working near the magnetron; the magnetic field will ruin the watch.

2. Do not work near the magnetron with magnetic tools.

a. Log the reading on the MAGNETRON TUNING dial, which is located on the front of Radar Receiver-Transmitter RT–212/TPS–1D, or preferably, if possible, log the original operating frequency as measured by Test Set TS–172A/UP (echo box).

b. With the equipment deenergized, withdraw the receiver-transmitter from its case as far as the chassis catches will allow.

c. Remove the flexible frequency control shaft by loosening the knurled coupling fitting that attaches the flexible cable to the magnetron at the flexible cable socket on the magnetron (fig. 32).

d. Remove the magnetron filament connector (fig. 32) from the glass end of the magnetron.

e. Free the magnetron by loosening the ring nut nearest to the magnetron on the magnetron output connector fitting, that can be seen through a rectangular access opening on the right side of the receiver-transmitter (fig. 33).

Note. Use the magnetron tool (fig. 19) provided in Case CY–1060/TPS–1D to loosen the ring nut. It is inserted in holes located around the edge of the ring nut.

f. Carefully withdraw the magnetron; be especially careful to prevent the end of the magnetron from being drawn against a pole piece of the magnet.

Caution: Use both hands to withdraw and insert the magnetron.

g. Before inserting the new magnetron into the output connector mounting, rotate the frequency adjustment gearing so that the frequency calibrating marks on the center and intermediate gear are alined (fig. 32).

Note. This tunes the magnetron to its midband frequency.

h. Carefully insert the new magnetron (type 5J26 tube) into the magnetron socket on the output connector mounting with the frequency adjustment fitting toward the right side of the receiver-transmitter.

i. Position the sides of the magnetron evenly and squarely between the magnet pole pieces, and securely tighten the ring nut nearest to the magnetron on the magnetron output connector fitting.

j. Tune the MAGNETRON TUNING control on the front of the receiver-transmitter to 500 (5 on the top dial and 0 on the large dial). This reading represents the magnetron midband frequency.

Note. The number on the top dial will change by one for each revolution of the large dial. Readings can be obtained from 0 to 1,000, which represents the frequency range of the magnetron (1220–1350 mc).

k. Insert the flexible frequency control shaft into the flexible cable socket on the magnetron, and tighten the knurled coupling fitting which attaches the flexible cable to the magnetron.

l. Plug in the magnetron filament connector at the glass end of the magnetron, and close the receiver-transmitter unit.

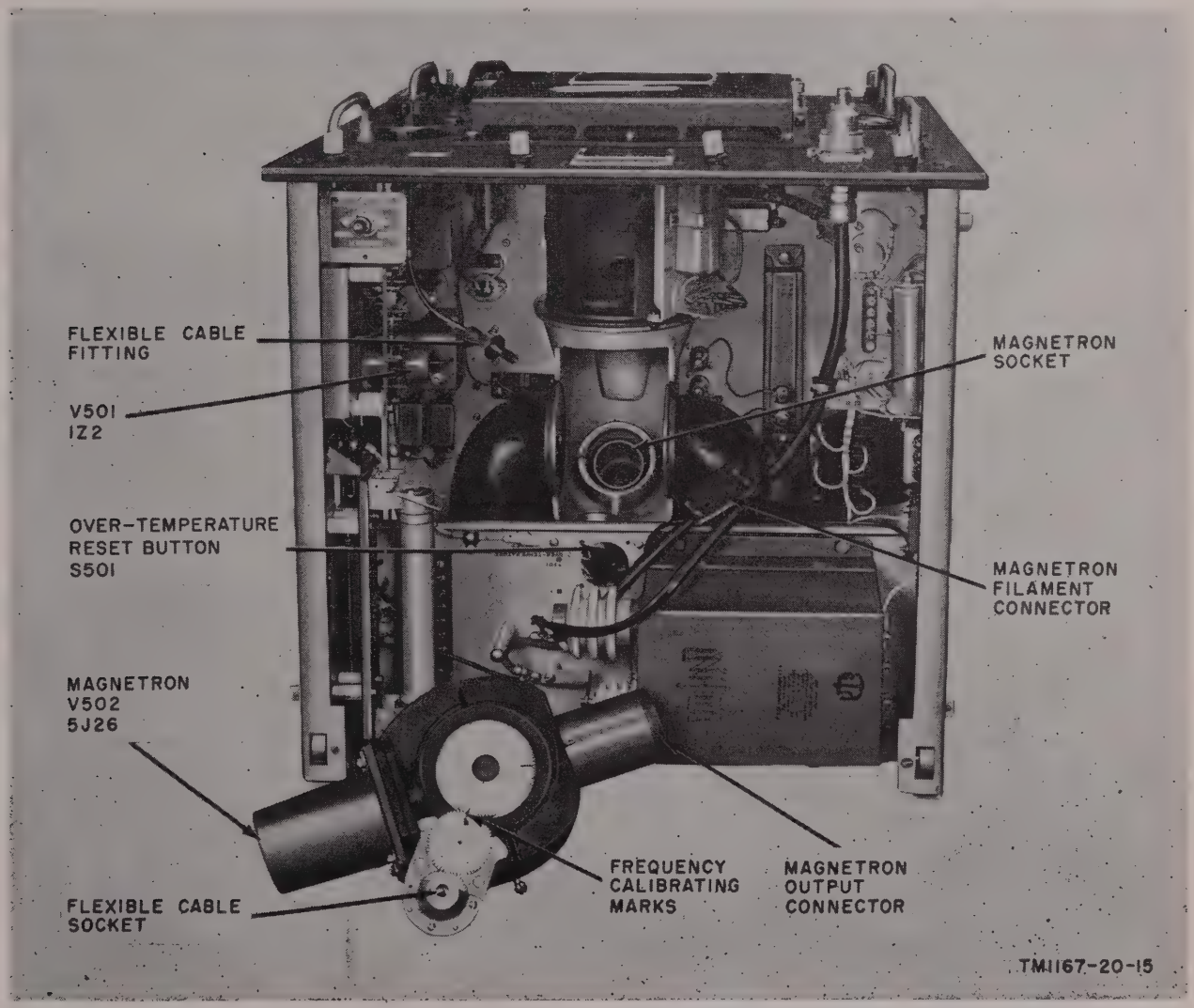


Figure 32. Receiver-transmitter details, top side.

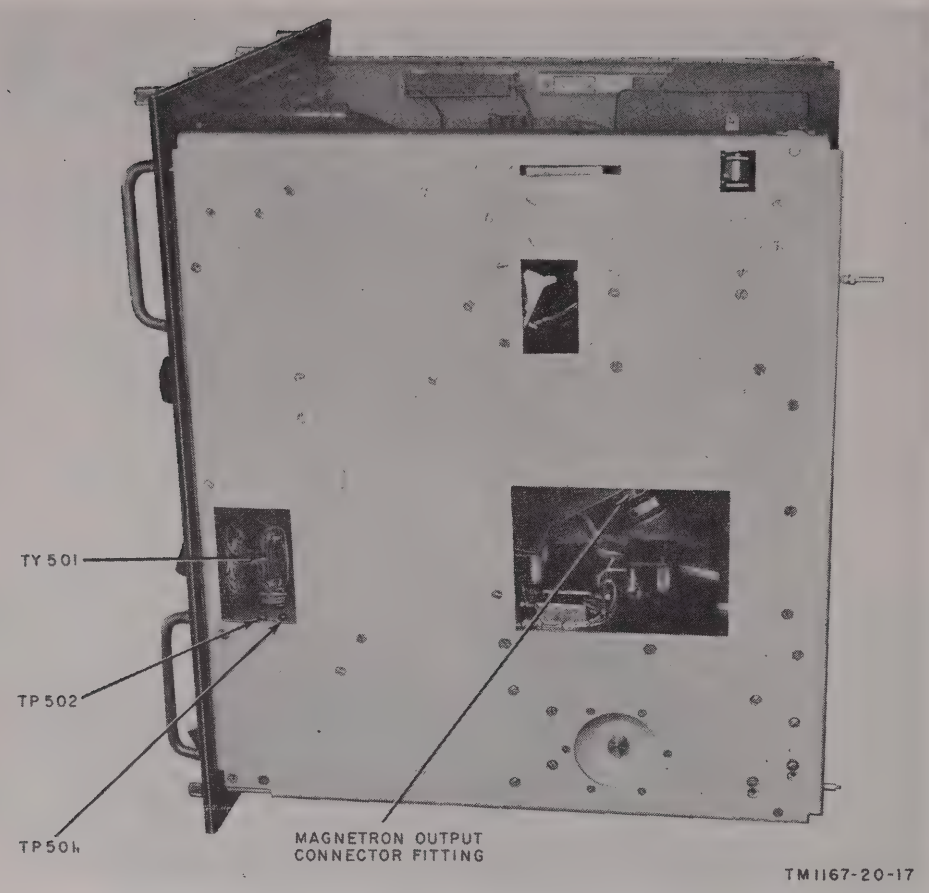


Figure 33. Receiver-transmitter details, right side.

m. Energize the equipment, and after the warmup period, tune the magnetron to the original operating frequency (*a* above). Age the magnetron as explained in paragraph 8*a*(1) (*a*).

35. Replacement of Local Oscillator Tube V505 (fig. 34)

a. With the equipment deenergized, withdraw the receiver-transmitter from its case as far as the chassis catches will allow.

b. Loosen the two knurled thumb nuts adjacent to the V505 socket XV505.

Note. To gain access to the bottom of the receiver-transmitter, loosen the Dzus fasteners that secure the forward section (access door) of the hinged shield beneath the chassis.

c. Withdraw the plate on which XV505 is mounted complete with V505 in its socket.

d. Remove V505, from XV505, and install replacement tube (type 2C40) in XV505.

e. Carefully insert V505, complete with XV505 and mounting plate, straight into the opening for V505 in the local oscillator assembly Z511. Make certain that it is seated properly.

f. Secure the mounting plate for XV505 by tightening the two knurled thumb nuts adjacent to XV505.

g. Energize the equipment and after a 20-minute warmup period, check the local oscillator cathode tuning adjustments as follows:

(1) On the front of the receiver-transmitter, place the TEST SELECTOR switch in the SIG position; check for an indication of crystal current on the test meter located above the TEST SELECTOR switch. If there is less than a red-line crystal current reading on the test meter, adjust the signal mixer-local oscillator coupling for a red-line reading by turning the signal mixer coupling adjustment after loosening the knurled ring nut that locks the coupling adjustment.

(2) On the front of the indicator, hold the L.O. MOTOR switch in the DEC position for approximately 30 seconds. This causes the local oscillator tuning motor to run until the low end of the frequency band is reached.

(3) While observing the reading on the test meter located above the TEST SELECTOR switch on the receiver-transmitter, increase the local oscillator frequency by holding the L.O. MOTOR switch in the INC position until the local oscillator tuning motor stops running at the high end of the frequency band. If approximately a red-line crystal current reading is obtained over the entire frequency range of the local oscillator or if a red-line reading can be obtained at all frequencies by adjusting the signal mixer-local oscillator coupling ((1) above), no local oscillator cathode tuning adjustment is required. If the above crystal current indication is not obtained, adjust the local oscillator cathode tuning adjustments in conjunction with the signal mixer coupling adjustment so as to obtain a red-line crystal current reading over the entire frequency range of the local oscillator. There are five cathode tuning adjustments and it may be necessary to adjust one or a combination of several of them. Initial adjustments should be made for maximum crystal current at approximately the local oscillator midband frequency. It may be tuned in by performing the procedure in (2) above, followed by operation of the local oscillator tuning motor in the reverse direction for one-half of the time required for the tuning motor to run from the stopped position at the low end of the frequency band to the stopped position at the high end of the frequency band. The click of a limit switch can be heard in the vicinity of the local oscillator when either end of the frequency band is reached.

Caution: While performing this procedure, do not allow crystal current to go substantially above the red-line indication.

h. Complete the local oscillator alinement procedure in the normal receiver alinement explained in paragraph 13.

i. Adjust the signal mixer-local oscillator coupling for a red-line reading on the test meter located above the TEST SELECTOR switch (*g*(1) above). Place the TEST SELECTOR switch in the COHO position and adjust the coho mixer-local oscillator coupling for a red-line reading on the test meter located above the TEST SELECTOR switch by turning the coho mixer coupling adjustment after loosening the knurled ring nut that locks the coupling adjustment. Lock the coupling adjustments.

j. Secure the hinged access door on the shield beneath the receiver-transmitter chassis, and close the unit.

36. Replacement of Pre-Tr Tube V503 and Tr Tube V504

(figs. 34 and 35)

Warning: Type 6322 transmit-receive (tr) tubes, used in this radar set, are radioactive. Dangers of poisoning from the radioactive materials contained in the tubes exist when the tubes are broken. For detailed instructions on handling, storing, and disposing of radioactive tubes, see TB SIG 225, Radioactive Tube Handling.

To replace either V503 or V504, proceed as follows:

a. With the equipment deenergized, pull the receiver-transmitter chassis out as far as the catches on the chassis allow, and open the hinged position of the shield beneath the chassis.

b. Remove cap E506 (fig. 34) from V504.

c. Remove P515 on cable W504 and P514 on cable W503 from RF503A.

d. Remove the two leads connected to terminal board E553.

e. Slightly loosen the two clamping screws on the clamps that hold the duplexer assembly RF503 to RF501 and carefully slide RF503 as far as possible toward the front of the receiver-transmitter.

f. Loosen the clamping screws until RF503 is free, and remove the entire assembly from the

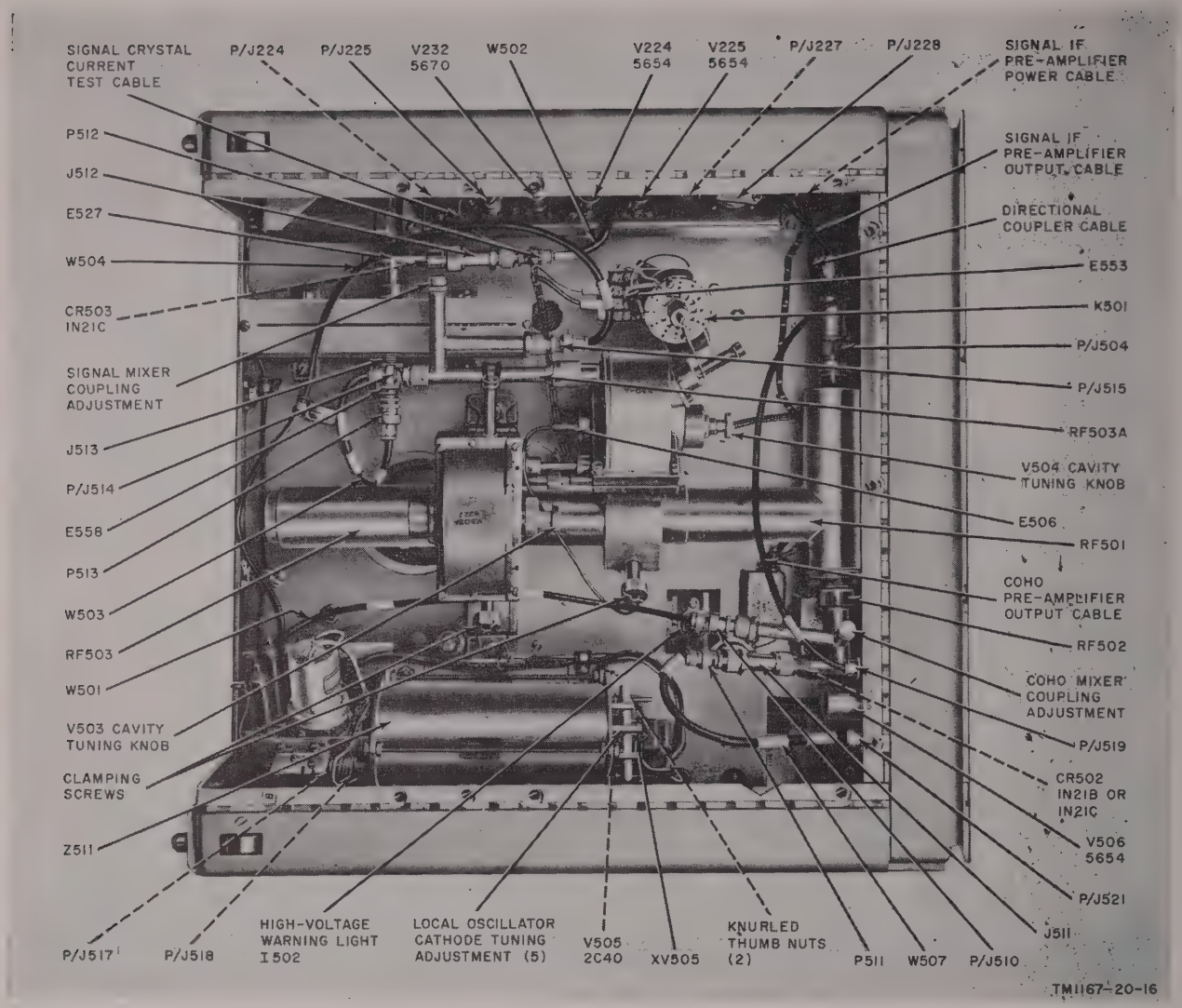


Figure 34. Receiver-transmitter details, bottom side.

receiver-transmitter chassis. If necessary, remove the shield from beneath the receiver-transmitter chassis by loosening the Dzus fasteners which are used to secure it.

g. Depending on whether V503 or V504 is being replaced, slightly loosen the four captive cavity screws (fig. 35) that bolt either the V503 or V504 cavity halves together. Unscrew the two knurled retaining rings and after the retaining rings have been removed, loosen the four captive cavity screws until the cavity halves can be separated and the tr tube can be removed.

Note. When separating the V504 cavity halves, remove the stem screw that holds RF503A to the cavity stem that is attached to one of the V503 cavity halves, or loosen the coupling that holds RF503A to one of the V504 cavity halves.

h. Carefully wipe the contact surfaces and the glass between the flanges of the replacement tr tube (type 6322) with a clean, dry cloth.

i. Carefully install the replacement tr tube between the cavity halves.

Note. The tube must be installed so that the tuning knob will face toward the front panel of the receiver-transmitter. The cavity contact surfaces must be between the tube flanges so that the knurled retaining rings will press the flanges against these surfaces. When V503 is being replaced, remove the long tuning shank from the old tube by loosening the screw at the end of the tuning knob, and substitute this long shank for the short shank on the new tube.

j. Tighten the four captive cavity screws, and replace and hand-tighten the two knurled retaining rings.

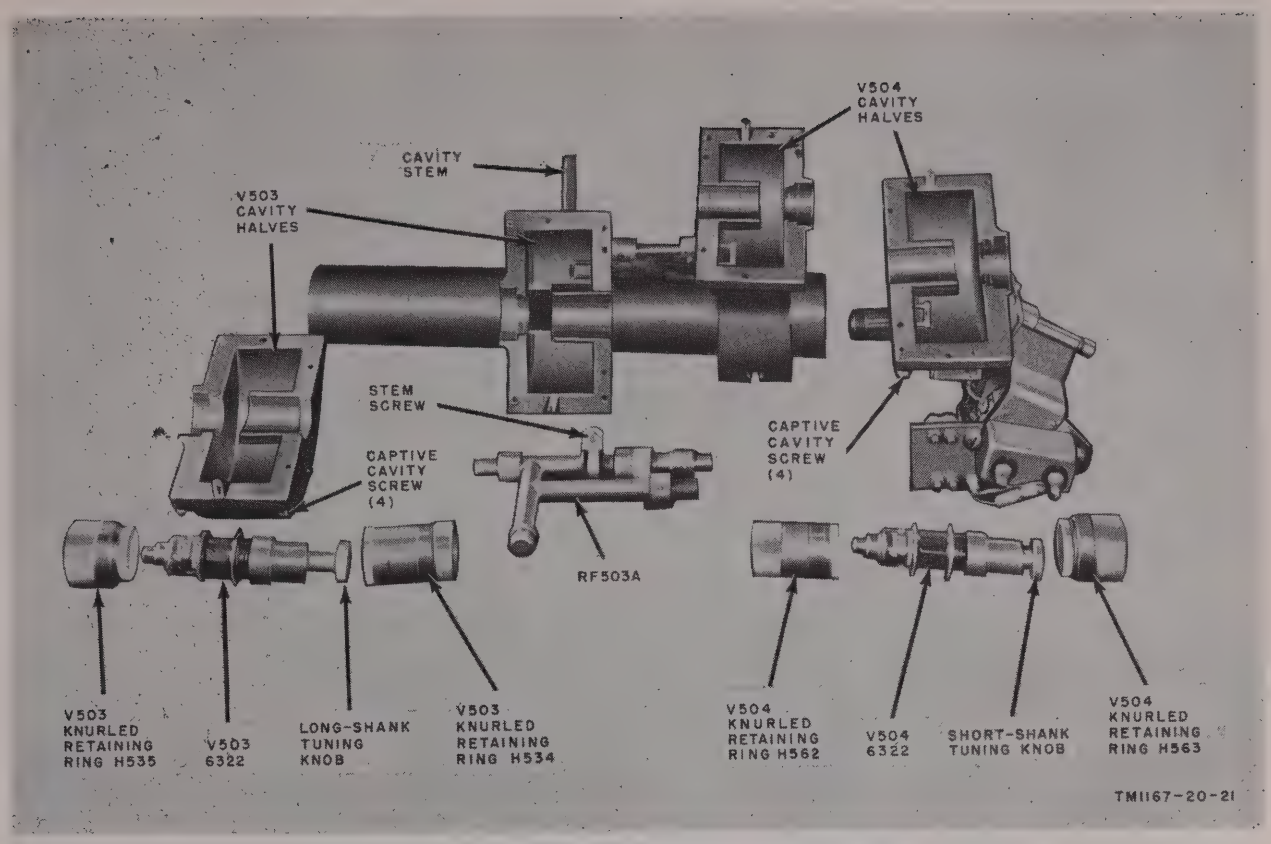


Figure 35. Duplexer assembly RF503 disassembled for replacement or tr tubes.

Note. After replacing V504, make certain that RF503A is attached securely to the V503 cavity stem and the V504 cavity.

k. Carefully install the entire assembly on RF501, and tighten the clamping screws, but allow enough slack so that RF503 can be moved forward or backward on RF501. Connect terminal board E553 leads, P514, P515, and cap E506 by reversing the procedures in *b, c,* and *d* above.

l. Replace the shield beneath the receiver-transmitter chassis, if removed during the tube replacement procedure.

m. Energize the equipment, and tune the tr cavity and adjust the position of RF503 on RF501 as outlined in paragraph 13.

n. Secure the hinged access door on the shield beneath the receiver-transmitter chassis, and close the unit.

37. Removal and Replacement of A-Scope Tube V625 and Ppi-Scope Tube V609

(figs. 23, 26, and 36)

Caution: When handling a ppi- or A-scope tube do not put pressure or strain on the neck of the tube. An implosion of a scope tube may cause fatal injuries.

a. Removal of A-Scope Tube.

(1) Remove power by setting the POWER switch to OFF.

(2) Remove the indicator unit entirely from its inner case by loosening the 16 captive panel screws and the 2 bottom fasteners.

(3) Remove the anode cap in the opening of the left side of the A-scope tube shield (fig. 26).

(4) Remove the four A-scope bezel screws and the A-scope panel bezel on the front panel; remove the A-scope tube bushing (fig. 36) and slowly withdraw the tube.

Note. It may be necessary to push on the tube base key at the center of tube socket XV625 (fig. 23). Be careful not to lose the four rubber grommets that cushion the A-scope tube.

b. Replacement of A-Scope Tube.

(1) Clean the face of the replacement A-

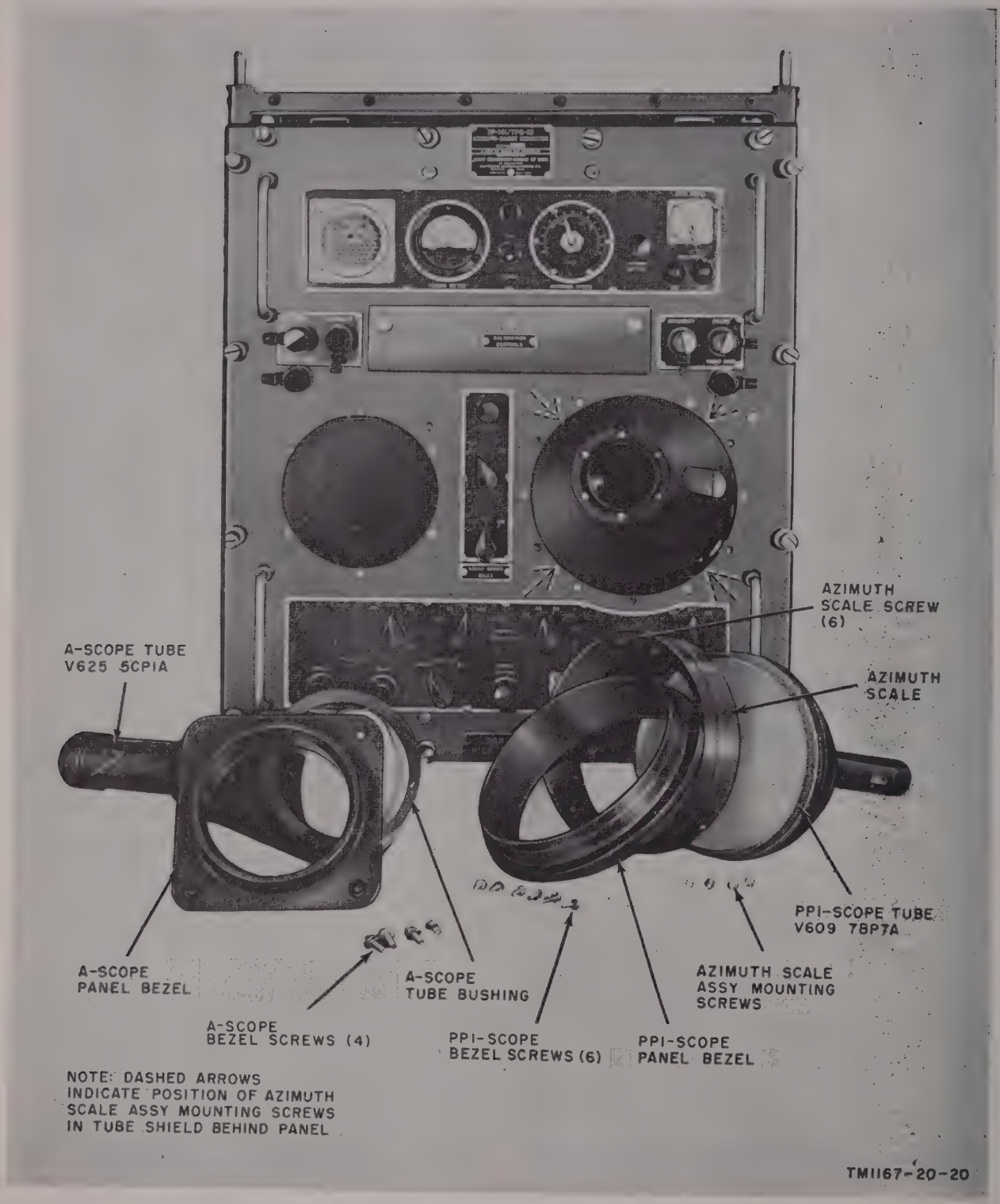


Figure 36. Replacement of scope tubes.

scope tube (type 5CP1A) with a soft damp cloth.

(2) Reverse the procedures in *a* above.

Note. A disarrangement of the rubber grommets inside the metal shield may prevent the crt from entering the shield.

(3) Adjustment of the A-scope sweep is outlined in paragraph 12.

c. Removal of Ppi-Scope Tube.

(1) Remove power by setting the POWER switch to OFF.

(2) Remove the indicator unit entirely from its inner case by loosening the 16 captive panel screws.

(3) Remove the anode cap (fig. 23).

(4) Loosen the tube socket clamp screw that secures the socket and clamp to the tube base, and remove tube socket XV609 by pulling straight outward on the hoop on the tube socket clamp.

(5) Remove the six ppi-scope bezel screws and then the ppi-scope panel bezel (fig. 36).

(6) Remove the azimuth scale assembly by first removing the four azimuth scale assembly mounting screws (fig. 23) located around the outside of the magnetic shield.

Note. Do not loosen the six azimuth scale screws (fig. 36) unless it is desired to substitute the mil scale (dial), contained in the spare parts case, for the azimuth scale marked in degrees, which is mounted in the azimuth scale assembly when the equipment is shipped.

(7) Carefully remove the ppi-scope tube.

d. Replacement of Ppi-Scope Tube.

(1) Clean the face of the replacement ppi-scope tube (type 7BP7A) with a soft damp cloth.

(2) Reverse the procedures in *c* above; be sure that the rubber cushion is present inside the Mumetal shield at the opening for the ppi-tube neck.

(3) Adjustment of the ppi-scope sweep is outlined in paragraph 12.

38. Replacement of Signal Crystal CR503 and Coho Crystal CR502 (fig. 34)

a. To replace signal crystal CR503, proceed as follows:

(1) With the equipment deenergized, pull the receiver-transmitter chassis out as far as the catches on the chassis will allow and open the hinged portion of the shield beneath the chassis.

(2) Disconnect J512 from the T-shaped crystal holder E527.

(3) Remove CR503, which is inserted into the open end of E527.

(4) Carefully wipe the contact surfaces of the replacement crystal (type 1N21C) with a clean, dry cloth. Hold the crystal at the base end only.

(5) Carefully insert the replacement crystal straight into the open end of E527; be careful to properly engage the crystal pin contact with the contacts inside the open end of E527.

Caution: Do not apply pressure to the end of the crystal unless the contacts are in alinement.

(6) Carefully wipe the crystal contacts in the open end of J512 with a clean, dry cloth.

(7) Connect J512 to E527.

Note. Make certain that the alinement pins on J512 fit into slots provided on E527.

(8) Energize the equipment.

(9) After the warmup period, check for a red-line crystal current reading on the receiver-transmitter test meter located above the TEST SELECTOR switch, with this switch in the SIG position. If necessary, adjust the signal mixer coupling adjustment (par. 35*g*(1)).

(10) Secure the hinged access door on the shield beneath the receiver-transmitter chassis, and close the unit.

b. To replace coho crystal CR502, proceed as follows:

(1) With the equipment deenergized, pull the receiver-transmitter chassis out as far as the catches on the chassis will allow, and open the hinged portion of the shield beneath the chassis.

(2) Disconnect J511 from coho mixer assembly RF502.

(3) Remove CR502 from the crystal holder in RF502.

(4) Carefully wipe the contact surfaces of the replacement crystal (type 1N21B

or 1N21C) with a clean, dry cloth. Hold the crystal at the base end only.

(5) Carefully insert the replacement crystal straight into RF502; be careful to properly engage the crystal pin contacts inside RF502.

Caution: Do not apply pressure to the end of the crystal unless the contacts are in alinement.

(6) Carefully wipe the crystal contacts in the open end of J511 with a clean, dry cloth.

(7) Connect J511 to RF502.

Note. Make certain that the alinement pins on J511 fit into slots provided on RF502.

(8) Energize the equipment.

(9) After the warmup period, check for a red-line crystal current reading on the receiver-transmitter test meter located above the TEST SELECTOR switch, with this switch in the COHO position. If necessary, adjust the coho mixer coupling adjustment (par. 35*i*).

(10) Secure the hinged access door on the shield beneath the receiver-transmitter chassis, and close the unit.

39. Repetition Rate Adjustment, Internal Trigger Operation

Repetition rate adjustment R110 (fig. 8) is in series with the REP. RATE CONTROL on the front of the modulator (fig. 54, TM 11–1167–10). R110 sets the pulse repetition rate limit to which the REP. RATE CONTROL can be adjusted when the TRIGGER switch on the front of the modulator is in the INTERNAL position. Indication of a variable pulse repetition rate can be obtained during transmission by observing the MAGNETRON CURRENT meter on the front of the receiver-transmitter while turning the REP. RATE CONTROL. As the control is turned ccw, the magnetron current reading should decrease. However, in addition to being variable from approximately 360 to 400 cycles per second, the pulse repetition rate of the radar set should be 400 cycles when the REP. RATE CONTROL is fully clockwise. Generally the REP. RATE CONTROL will be left in the extreme clockwise position. To adjust the frequency limit of the REP. RATE CONTROL, proceed as follows:

a. Turn the REP. RATE CONTROL to its full clockwise position.

b. Operate the oscilloscope from one of the convenience outlets (par. 3*d*) on the radar set, and connect a lead between its V INPUT jack and J153 on the front of the modulator. Adjust the oscilloscope for 2 pulses on the scope sweep.

c. Pull the modulator out of its case to the stopped position and disable the interlock. Unlock R110 and adjust for a time interval of 2,500 microseconds between the pulses on the oscilloscope, as measured with the markers on the oscilloscope.

CHAPTER 4
BASIC THEORY

Section I. FUNCTIONAL SYSTEM BLOCK DIAGRAM

40. General
(figs. 37 and 38)

For purposes of explaining and troubleshooting the equipment, the AN/TPS–1D is divided into eight functional systems, each of which performs one or more specific functions. The functions of each system, the relationship of each system to the overall radar set, and the interrelationship between systems are shown in the system functional block diagram (fig. 37), and are explained in paragraphs 41 through 48. The functional system block diagram may be used as an aid in sectionalizing equipment troubles to a particular system. A functional system may be physically located in a single major component, but in most cases a system is located in two or more major components of the equipment. The location and common names of the major components of the equipment are shown in figure 38. The components of the radar set are grouped into functional systems as follows:

a. Transmitting system.

b. RF system.

c. Receiving system.

d. Signal comparing system.

e. Indicating system.

f. Antenna positioning system.

g. Dc power supply system.

h. Ac power distribution and control system.

41. Transmitting System
(figs. 37 and 38)

The transmitting system produces 400 RF pulses per second, 2 microseconds in duration, at a nominal carrier frequency of 1,280 megacycles per second. The transmitting system consists of the trigger circuit (including a pulse-delay network), the transmitter high-voltage power supply, the keyer circuits in the modulator unit, and the pulse transformer and magnetron circuits in the receiver-transmitter. The number of pulses per second produced by the transmitting system (the pulse-repetition frequency (prf) of the equipment) may be established in one of two ways. Accurate external triggers are normally applied from the signal comparing system to the trigger circuit in the transmitting system. Internal timing pulses are also generated within the trigger circuit in the transmitting system but they are only used in case of emergency. The trigger circuit amplifies and shapes the internal or external triggers and produces pulses which actuate the keyer and pretrigger pulses which are used to trigger the associated iff equipment either 12.4 or 37 microseconds before the keyer is triggered. The transmitter high-voltage power supply provides high voltage (5,000 volts dc) for the keyer. The keyer develops high-voltage pulses exactly 2 microseconds in duration each time it is triggered by the trigger circuit. The pulse transformer steps up the output from the keyer and applies 30,000 volts negative pulse to the magnetron oscillator. The magnetron only oscillates during the application of the 2-microsecond pulses. The resulting pulses of RF energy are applied to the RF transmission lines which carry the RF energy to the antenna.

42. RF System
(figs. 37 and 38)

The RF system carries RF energy from the transmitting system to the antenna, which radiates the energy and picks up the returning RF energy (echoes), and carries the returning echoes to the receiving system. By functioning as an efficient transmit-receive switch, the RF system makes it possible to use the same an-

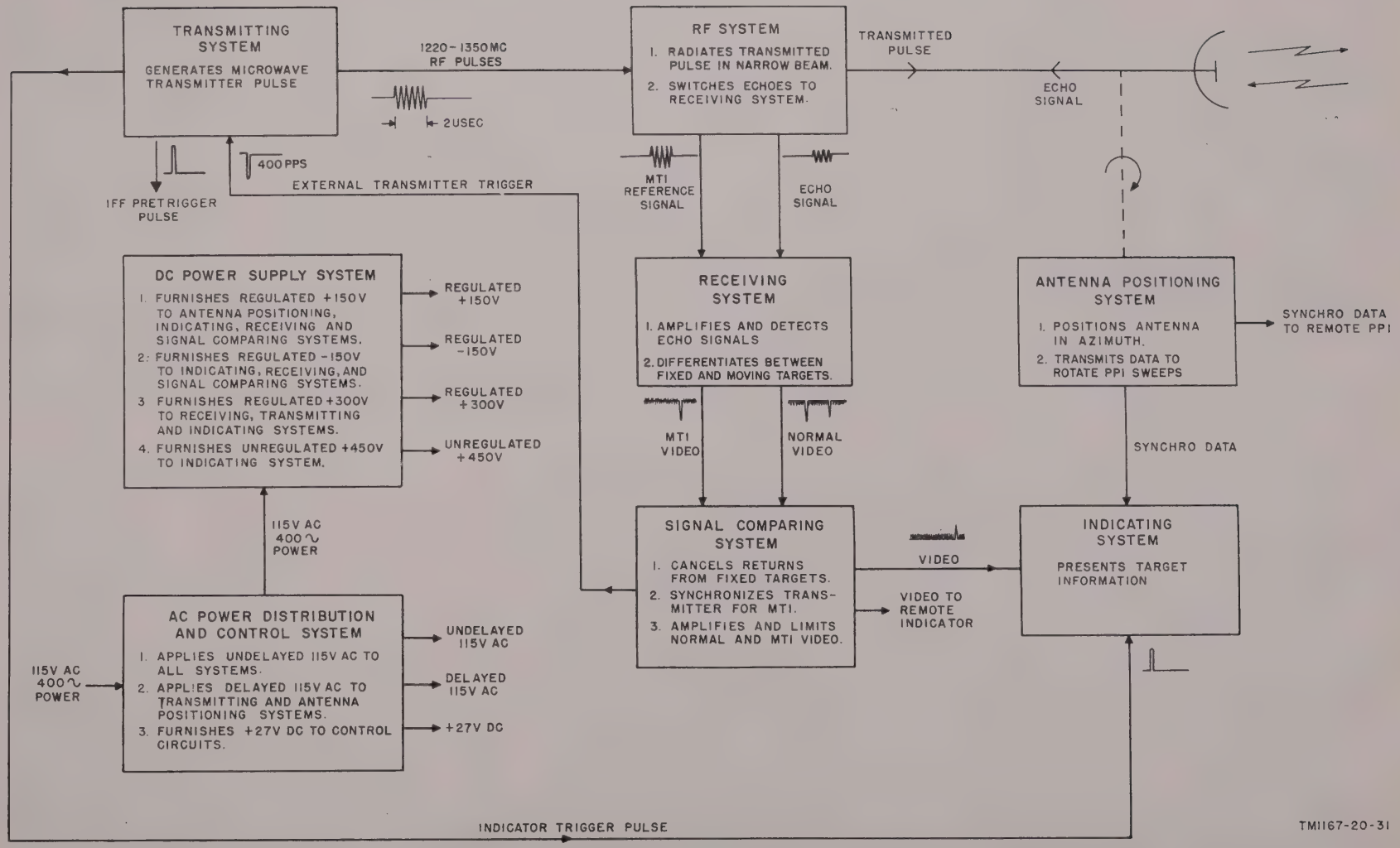


Figure 37. Radio Set AN/TPS–1D, system functional block diagram.

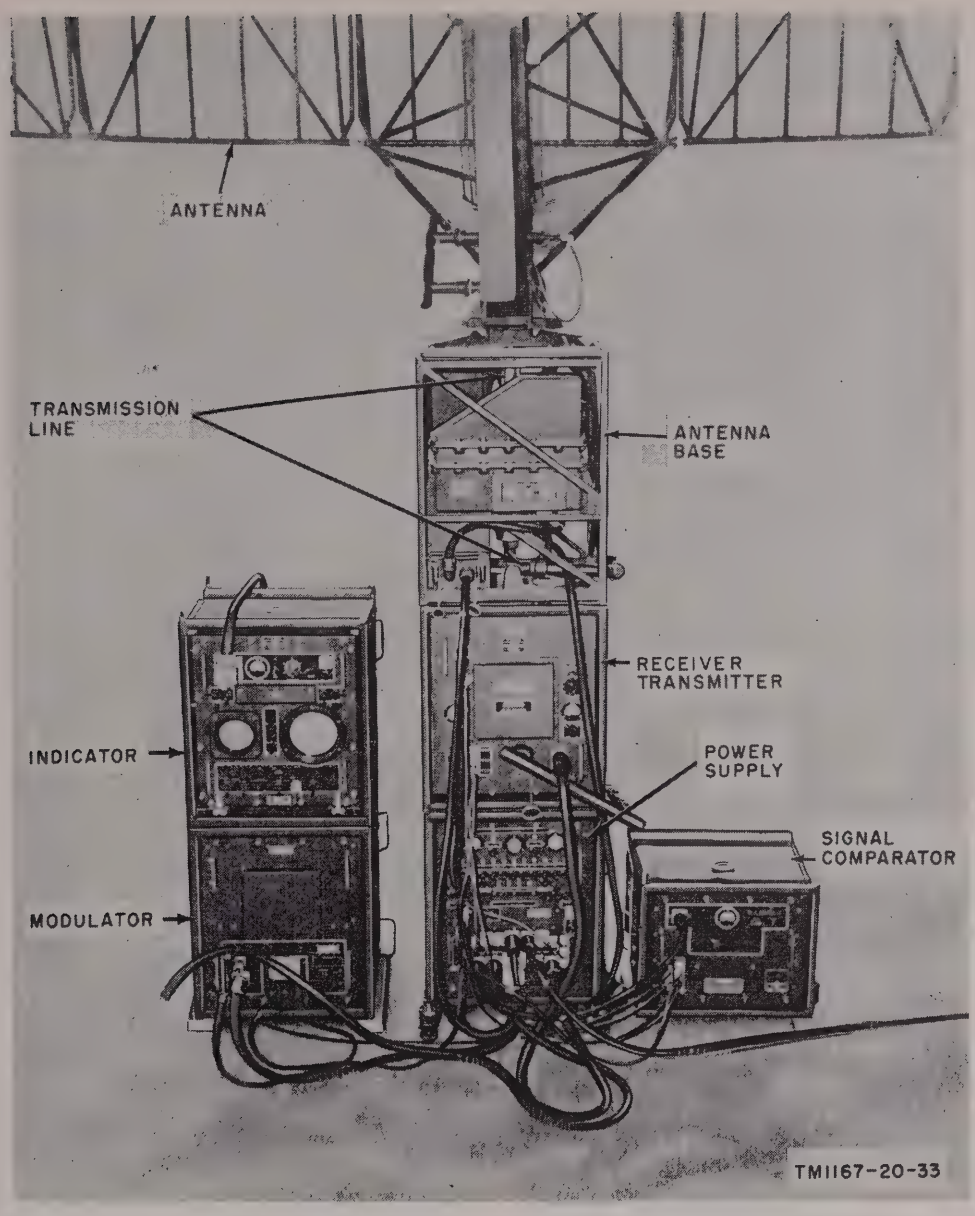


Figure 38. Radio Set AN/TPS–1D, major components.

tenna for transmitting and receiving. It also makes it possible for the antenna to be rotated through 360° of azimuth by means of a rotating joint in the antenna base portion of the RF transmission line. The RF system consists of the transmit-receive (tr) cavities assembly, the keep-alive power supply, and the directional coupler in the receiver-transmitter, the antenna, and all RF transmission line components that feed the antenna. The transmit-receive function is accomplished electronically by means of a duplexer assembly which consists of a pre-tr cavity and a tr cavity assembly. The keep-alive power supply furnishes approximately —800 volts to the tr cavity to speed up the tr switching action. When the transmitter fires, the tr cavities protect the receiving system by preventing the high-power transmitted pulses from entering the signal channel of the receiving system. The relatively weak returning echoes do not actuate the tr switch and are therefore applied to the signal channel in the receiving system. A fractional portion of the transmitted energy is coupled through the directional coupler to the R. F. TEST jack on the receiver-transmitter for system checking and alinement. A

small sampling of the transmitted energy is also coupled to the coho channel in the receiving system as a reference signal for mti purposes.

43. Receiving System
(figs. 37 and 38)

The receiving system amplifies the weak echo signals, differentiates between the echo returns from fixed and moving targets, and applies video pulses to the signal comparing system for further application to the indicating system. The receiving system consists of the local oscillator and control circuits, signal mixer, IF preamplifier, coho mixer, and coho preamplifier assemblies in the receiver-transmitter, the coherent oscillator and 60-mc IF amplifier (which includes the phase detector) assemblies in the signal comparator, and the RECEIVER GAIN potentiometer, TUNING meter, and local oscillator tuning switch (L. O. MOTOR) on the front panel of the indicator. The receiving system functions differently in the various modes of operation of the equipment. In the normal mode, the system operates as a conventional superheterodyne receiver. The phase detector operates as a normal receiver second detector, and negative video pulses (normal video), representing returns from all targets, are applied to the signal comparing system. In the mti mode, a coherent signal (a reference signal which is phase-locked to the transmitted signal) from the coho channel is applied to the phase detector along with the echo signals so that bipolar video pulses (mti video), representing returns from both stationary and moving targets, are applied to the signal comparing system. In the coho adjust mode, both the coherent signal and the echo signals are also applied to the phase detector. In this mode, normal video is applied to the signal comparing system to check and aline the coho channel circuits.

44. Signal Comparing System
(figs. 37 and 38)

The signal comparing system compares the returns from successive transmitted pulses and substantially cancels the returns from stationary targets so that only video pulses representing moving targets and small amounts of residue clutter are applied to the indicating system in the mti mode of operation. The signal comparing system also generates and supplies accurate external timing triggers to the transmitting system. In the normal and coho adjust modes of operation, the signal comparing system amplifies, limits, and then applies normal video to the indicating system. The signal comparing system consists of a 9-mc carrier channel, a delay channel (which includes a 2,500-microsecond mercury delay line), a nondelay channel, video circuits, amplitude balancing circuits, time balancing circuits, and a trigger generator circuit, all of which are in the signal comparator. Two potentiometers (RECEIVER AMPL BALANCE and MTI BALANCE) and one switch (OPERATION) on the front panel of the indicator are also part of the signal comparing system. These are remote controls which have equivalent components on the signal comparator which may be switched into the circuitry to make the adjustments at the signal comparator. In the mti mode, cancellation of the returns from stationary targets is accomplished by circuitry that delays the bipolar video pulses from the phase detector (in the receiving system) for a time exactly equal to the time between transmitted pulses. The delayed video pulses are then compared with the inverted returns from the following transmitted pulse (which are not delayed) so that the returns from stationary targets cancel and the returns from moving targets do not. The returns from stationary targets cancel when they are compared because they are equal in amplitude and opposite in polarity at the comparison point. The returns from moving targets (from the same targets but from successive transmitted pulses) do not cancel because they are not necessarily equal in amplitude nor the same polarity when they are compared. This is because the phase of the RF signal returned from a moving target changes from pulse to pulse due to the change in distance to the target from pulse to pulse. The difference in phase of the echo signal from pulse to pulse results in different pulse amplitudes and, in some cases, differences in polarity in the output from the phase detector from pulse to pulse. This pulse-to-pulse comparison method causes resultant video pulses which represent moving targets to be developed at the comparison point. These video pulses are amplified, limited, and applied to the indicating system. In the normal and coho adjust modes of operation, video pulses representing the re-

turns from all targets (normal video) are applied to the indicating system.

45. Indicating System
(figs. 37 and 38)

The indicating system displays video pulses which represent targets on a 7-inch ppi scope and a 5-inch A-scope. The indicating system consists of the ppi-scope sweep and display circuits, A-scope sweep and display circuits, fixed range marker circuits, the variable range strobe generator, video amplifier and mixer circuits, and indicator high-voltage power supply, all in the indicator unit. The ppi sweep circuits are triggered by the indicator trigger from the transmitting system so that the sweep, or time base, on the ppi scope starts when the transmitter fires. The ppi sweep circuits generate a radial sweep which extends from the center of the screen to the outer edge of the screen. Synchro stator information is applied from the antenna positioning system to the indicating system to make the ppi sweep follow antenna rotation. A scale which is calibrated in degrees or mils appears around the circumference of the ppi screen so that the azimuth of targets may be determined directly from the ppi scope by observing the position of the sweep. The fixed range marker circuits generate 5- or 25-mile range markers which are displayed on the ppi screen as concentric circles. Video pulses from the signal comparing system are amplified by the video circuits in the indicating system and are displayed as intensified spots on the ppi screen. Thus, the indicator trigger, synchro data, and video inputs make it possible to determine the range and azimuth of targets in all azimuths as the antenna is rotated continuously. The A-scope sweep circuits may be triggered by the indicator trigger so that the sweeps on the A scope also start when the transmitter fires or they may be triggered by a delayed trigger produced by the range strobe generator. A variable trigger from the range strobe generator triggers the start of a 10-mile expanded sweep on the A scope and at the same time the variable trigger is displayed on the ppi scope to show the range at which the expanded sweep starts. Video pulses and 5- or 25-mile range markers are displayed on the A scope so that the range of targets at a particular azimuth may be determined by observing the A scope. The indicator high-voltage power supply produces high-voltage dc potentials necessary for the operation of the two cathode-ray tube indicators.

46. Antenna Positioning System
(figs. 37 and 38)

The antenna positioning system controls the driving power necessary to rotate the antenna, the ppi sweep, and the remote ppi sweep. The antenna positioning system consists of the antenna servo amplifier, antenna drive assembly, and two synchro transmitters in the antenna base unit, and the antenna rotate control mechanism and synchro receiver (which drives the ppi sweep) in the indicator. A dc control voltage is applied from the antenna rotate control mechanism to the antenna servo amplifier to control the speed and direction of antenna rotation from the operating position at the indicator. The antenna servo amplifier provides the driving power for the antenna drive motor in the antenna drive assembly. The motor in turn drives a gear train which drives the antenna, the remote ppi synchro transmitter rotor, and the synchro transmitter that supplies stator information to the indicating system. The remote ppi synchro transmitter rotor is driven at the same speed as the antenna, and the synchro transmitter that supplies stator information to the indicating system is driven at a speed 24 times that of the antenna. The 24-speed synchro system increases the accuracy of the ppi sweep positioning with respect to the antenna position. A synchro self-zeroing circuit is employed in the positioning of the ppi sweep to prevent the synchro receiver which drives the ppi sweep yoke from taking an erroneous position.

47. Dc Power Supply System
(figs. 37 and 38)

The dc power supply system furnishes dc operating potentials to stages throughout the equipment. The dc power supply system consists of a positive rectifier, a negative rectifier, +300-volt and +150-volt series-regulator circuits, and three —150-volt shunt regulators, all located in the power supply. Undelayed 115 volts ac power is applied to the dc power supply system from the ac power distribution and control system. The dc power supply system furnishes the specific dc potentials to the systems listed in the dc power supply system block in figure 37.

48. Ac Power Distribution and Control System
(figs. 37 and 38)

The ac power distribution and control system controls the application of all 115 volts, 400 cycles ac and +27-volt dc power throughout the equipment. In addition to the +27-volt dc power supply and the control chassis (which includes the 5-minute time delay circuit) in the power supply, the system consists of all circuitry which controls the application of ac power to components which use 115 volts, 400 cycles directly, such as transformers, blower motors, heaters, indicating lamps, and synchro components. All fuses, blown-fuse indicators, and interlocks are a part of the ac power distribution and control system, because they are used to control the distribution circuits of ac power and +27-volt dc power throughout the equipment. The +27-volt dc power supply and the distribution of +27 volts dc are part of the system because +27 volts dc is used to actuate relays which control the application of power to all systems. Undelayed 115 volts ac is applied to all systems and delayed 115 volts ac is applied to the transmitting and antenna positioning systems. Undelayed +27 volts dc is applied to the filaments of the local oscillator, the local oscillator tuning motor, and the 5-minute time-delay circuit. Delayed +27-volts dc is applied to control relays in the antenna positioning, signal comparing, receiving, RF, and transmitting systems.

Section II. COMPLETE BLOCK DIAGRAM

49. General
(fig. 40)

A thorough knowledge of the complete block diagram of a radar system is important to the understanding of how the equipment operates and it is necessary when troubleshooting the overall equipment or a particular functional system. The complete block diagram of the AN/TPS–1D (fig. 40) shows the functional systems of the equipment inclosed in heavy solid lines, the subsystems (channels, or circuit groups) inclosed in lighter broken lines, and each stage and some of the key component parts within the subsystems. The complete block diagram can be used as a quick review of the basic theory of the equipment by a radar repairman who has not worked with the equipment for some time. The diagram also enables the repairman who is familiar with radar principles and equipments in general but who is not acquainted with this particular equipment to gain a basic understanding of the systems, subsystems, and stages of the equipment and their interrelationship.

a. The organizational maintenance man can locate most of the equipment failures, because most troubles are caused by faulty vacuum tubes. When troubleshooting, the functional system block diagram and complete stage-by-stage block diagram will enable the repairman to sectionalize troubles to a system by observing symptoms. In many cases, the most common troubles may be narrowed down to a group of stages or a particular stage within the equipment by a stage-by-stage block diagram analysis. This type of troubleshooting is important because it can frequently enable the repairman to eliminate considerable operating time loss which results when the equipment is shut down for repairs.

b. The important timing relationships within the equipment are discussed in paragraph 50. A detailed stage-by-stage block diagram analysis of the functional systems of the equipment is given in paragraphs 55 through 86.

50. Timing
(figs. 39 and 40)

The timing and synchronization of the AN/TPS–1D circuits is very critical in the mti mode of operation because the cancellation of the returns from stationary targets requires accurate timing. The pulse-to-pulse comparison methods of mti (par. 44) requires an exact time between transmitted pulses and, for this reason, the transmitter is triggered by synchronizing circuits in the signal comparing system (pars. 70 and 71). In all modes of operation, proper synchronization of the equipment is necessary to obtain range measurements.

a. When the set is turned on, power is applied to all filament and plate transformers in the set except for the plate transformer in the modulator high-voltage power supply and the plate transformer in the servo amplifier in the antenna positioning system.

b. The carrier gate multivibrator (V1353B

and V1354) in the 9-mc carrier channel of the signal comparing system is the master oscillator of the equipment. It is a free-running multivibrator which is synchronized by the trigger loop circuits (par. 70) so that its period of oscillation is equal to the amount of time delay in the delay channel (approximately 2,500 microseconds). The actual period of oscillation is not as important as the fact that the timing of the multivibrator depends upon the exact delay in the delay channel. One output from the carrier gate multivibrator gates the 9-mc carrier oscillator (V1355). The gated 9-mc oscillations (wave form 1) are amplified and delayed in the delay channel, and the delayed leading edge of the demodulated envelope is used to obtain a pulse which synchronizes the timing of the carrier gate multivibrator so that its timing depends upon the amount of delay in the delay channel. A negative gate (waveform 2) is applied from the carrier gate multivibrator to the trigger generator (V1353A) which operates as a shock-exited oscillator. The trigger generator produces a critically damped sine wave (waveform 3) with each alternation taking 10 microseconds. The leading edge of the first positive alternation is used to obtain negative triggers (waveform 4) which occur exactly 10 microseconds after the carrier gate oscillations begin. The negative triggers are applied from the trigger amplifier (V1352) to the trigger circuit in the transmitting system when the TRIGGER switch is in the EXTERNAL position. The 10-microsecond time delay obtained from the trigger generator prevents returning echoes from nearby targets (which modulate the 9-mc carrier oscillations for mti purposes) from affecting the timing of the system.

c. The negative external trigger pulses from the signal comparing system are applied to blocking oscillator keyer V102A which triggers blocking oscillator V1101A in the pulse-delay network. Two outputs are taken from blocking oscillator V1101A. A positive iff pretrigger pulse (waveform 5) is taken from the cathode circuit and applied to the associated iff equipment. A negative pulse is taken from the plate circuit of V1101A and the remainder of the pulse-delay network produces negative pulses (waveform 6) which are delayed by either 12.4 or 37 microseconds with respect to the iff pretrigger pulses depending upon the position of a selector switch. The delayed negative output pulses from the pulse-delay network are converted to large positive pulses by the trigger circuit and applied to the keyer circuits.

d. Five minutes after power has been applied to the set, the 5-minute time-delay circuit in the ac power distribution and control system makes it possible to apply power to the high-voltage rectifiers in the high-voltage power supply and control circuits in the transmitting system and to the plate transformer which supplies the control rectifiers in the servo amplifier of the antenna positioning system.

e. When high voltage is applied to the keyer circuits and the output positive trigger pulses from the trigger circuit are also applied to the keyer circuits, the keyer circuits produce a negative 2-microsecond pulse with a rapid fall and rise time (waveform 7). The output from the keyer circuits is applied to the magnetron (V502) through the pulse transformer (T502) so that the magnetron oscillates (waveform 8) during the time that the negative pulse is applied from the keyer. At the same time that the magnetron starts to oscillate, a positive pulse (waveform 9) is also taken from the pulse transformer and applied to the indicating system. This indicator trigger, which begins at time T_0 and coincides with the transmitted pulse, triggers the sweeps (time bases) and range marker circuits in the indicating system so that time is measured from the exact time that the transmitter is pulsed.

f. The indicator trigger is applied to the following four circuit groups in the indicating system:

(1) The ppi gate multivibrator (V603) produces a negative gate (waveform 11) which controls the output from the ppi sweep generator (V604). The ppi sweep circuits produce a trapezoidal sweep voltage (waveform 12) which causes a linear sawtooth of current to flow through the ppi deflection coil so that a linear sweep is formed on the face of the ppi scope. During sweep time, a ppi unblanking gate (waveform 10) is applied from the ppi gate multivibrator to the ppi scope to allow beam current to flow in the ppi scope during sweep time. The time duration of the

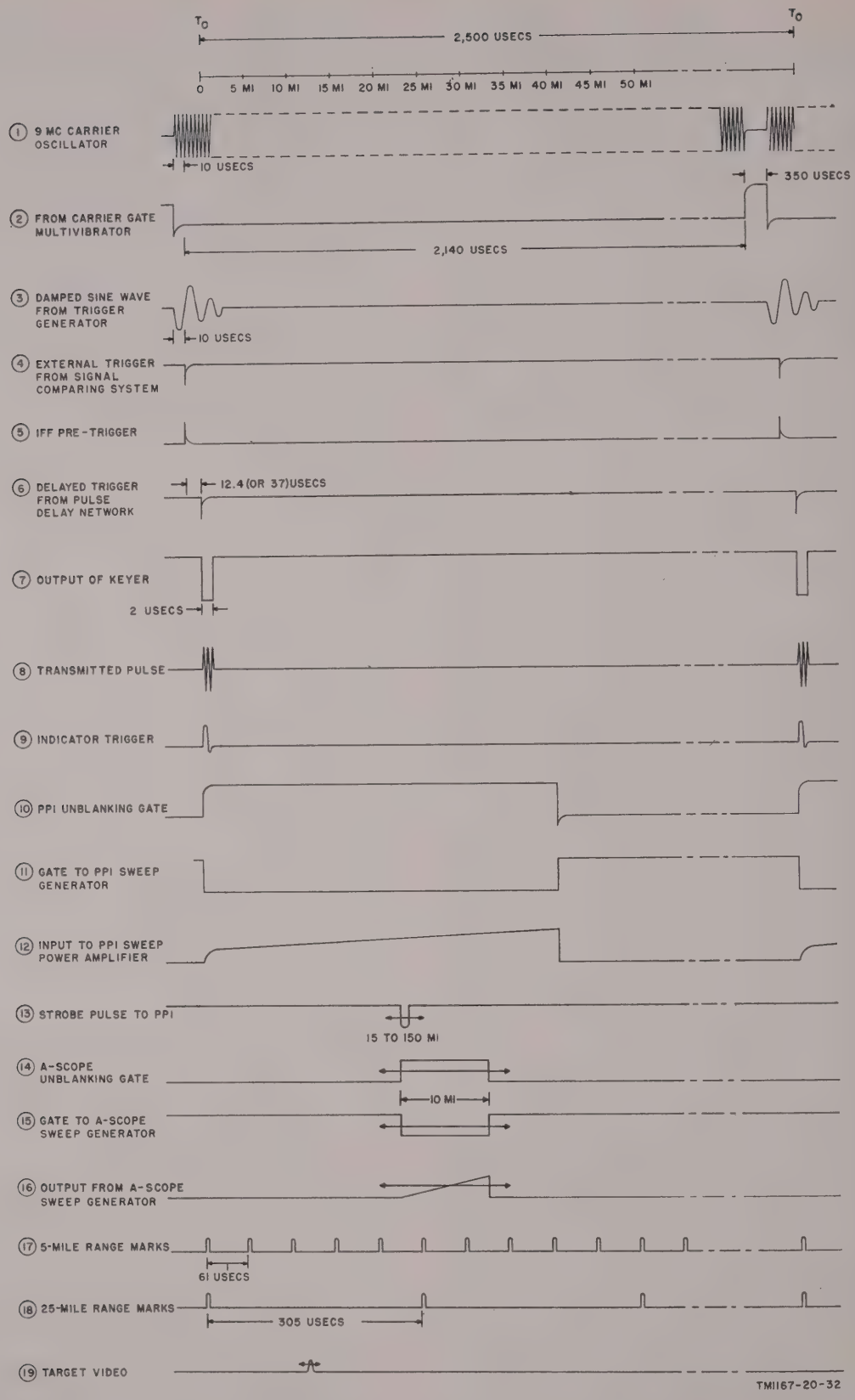


Figure 39. Radio Set AN/TPS–1D, timing diagram.

gating and sweep waveforms (waveforms 10, 11, and 12) may be 20, 40, 80, or 160 miles, depending upon the position of the PPI RANGE SELECTOR switch.

(2) The range strobe multivibrator (V621) produces a variable time delay with respect to the indicator trigger. The amount of time delay is controlled by the setting of the RANGE STROBE potentiometer and it is variable from approximately 15 miles to 150 miles. Two outputs are taken from the range strobe generator circuits. One is a negative pulse (waveform 13) which is applied to the ppi scope. This negative pulse causes an intensified spot to appear on the ppi scope at a range which depends upon the amount of delay produced by the range strobe multivibrator. The other output from the range strobe generator circuit is a positive pulse which coincides in time with the range strobe. This positive pulse triggers the A-gate multivibrator (V622) when the A RANGE SELECTOR switch is in the EXP position.

(3) The A-scope sweep circuits are triggered by the indicator trigger when the A RANGE SELECTOR switch is in the 20, 40, 80, or 160 position. In these switch positions, the A-scope sweep circuits produce gate and sweep voltages similar to the ppi waveforms except that a sawtooth sweep voltage is produced rather than a trapezoidal one. The time duration of the output waveforms corresponds to the position of the A RANGE SELECTOR switch. In the EXP position of the A RANGE SELECTOR switch, the A-gate multivibrator is triggered by the delayed positive trigger from the range strobe generator circuit. In this position of the selector switch, an expanded 10-mile sweep, which starts at the range of the range strobe, is displayed on the A scope. A variable 10-mile negative gate (waveform 15) is applied from the A-gate multivibrator to the A sweep generator which produces a sawtooth sweep voltage (waveform 16) during the application of the negative gate. The output from the A-scope sweep generator is applied to a paraphase amplifier which produces push-pull sweep voltages which form the 10-mile expanded sweep on the A scope. During expanded sweep time, an A-scope unblanking gate (waveform 14) is applied from the A-gate multivibrator to the A scope to allow beam current to flow.

(4) The marker gate multivibrator (V614) produces a gate slightly longer than 160 nautical miles. During this time, the fixed range marker circuits produce range markers which occur every 61 microseconds (waveform 17) and range markers which occur every 305 microseconds (waveform 18) with respect to the transmitted pulses. The 61-microsecond markers are equivalent to 10,000 yards or approximately 5 nautical miles of radar range. The 305-microsecond markers are equivalent to 50,000 yards or approximately 25 nautical miles. Normally, 5-mile markers are displayed on the 20- and 40-mile sweeps of both scopes, 25-mile markers are displayed on the 80- and 160-mile sweeps on both scopes, and 5-mile markers are displayed on the expanded sweep on the A scope. There is provision for not displaying range markers and also for displaying both 5- and 25-mile markers on the 80- and 160-mile sweeps.

g. Video pulses representing all targets are displayed on both scopes in the normal mode of operation and video pulses representing moving targets are displayed on both scopes in the mti mode of operation (waveform 19).

Section III. TRANSMITTING SYSTEM

51. General
(fig. 40)

The transmitting system produces pulses of RF energy when it is triggered. The pulse width of the RF energy is accurately established as 2 microseconds by the pulse-forming network in the keyer circuits. The pulse-repetition frequency of the equipment is 400 pulses per second (pps) when the transmitting system is normally triggered by external triggers from the signal comparing system, and it is variable between 360 and 400 pps when internal triggers are used for emergency operation.

a. Peak power output of the transmitting system is approximately 500 kilowatts and the RF carrier frequency is adjustable through a frequency range of 1,220 to 1,350 megacycles per second (mcs).

b. The transmitting system provides two important timing pulses to other circuits. An iff pretrigger is applied from J157 to associated iff equipment either 12.4 or 37 microseconds before the transmitter is pulsed. A timing pulse is applied to the indicating system (indicator trigger) from pulse transformer T502 at the same time that the transmitter is pulsed.

52. High-Voltage Power Supply and Control Circuits
(fig. 40)

The high-voltage power supply provides the transmitting system with operating power. The control circuits provide a means of applying input power and disconnects the input power when abnormal loading conditions occur.

a. Radiate relay K152 connects 115 volts ac power to the primary of the high-voltage transformer which furnishes plate potentials to high-voltage rectifier tubes V151 and V152 when the RADIATE switch on the indicator is pressed.

b. The high-voltage rectifier tubes are connected as a conventional full-wave rectifier circuit. They provide a 5-kilovolt (kv) dc output to the dc series-resonant charging circuit in the keyer circuits.

c. Protective relay K151 is a differential relay with two coils. Current drawn from the high-voltage power supply flows through one coil, and current through the shunt diode in the keyer circuits flows through the other coil. Normally, the currents through the two coils are balanced and the relay is normally deenergized. Relay K151 energizes and removes power from the high-voltage power supply if any of the following conditions occur:

(1) Short or arcing in RF system.
(2) Shorted magnetron.
(3) Magnetron not oscillating.
(4) Intermittent oscillating of magnetron.
(5) Mode changing of magnetron.
(6) Magnetron arcing or excessive sparking.
(7) Failure of magnetron filament supply.
(8) Open or shorted windings of pulse transformer.
(9) Failure of shunt diode.
(10) Open winding of either coil of K151.

53. Trigger Circuit
(fig. 40)

The trigger circuit amplifies and shapes the triggers which actuate the thyratron keyer tube in the keyer circuits. It also includes a pulse-delay network which provides output iff pretrigger pulses to the associated iff equipment and then delays the pulses which are applied to the keyer circuits. In this way, the iff equipment is triggered before the transmitter of the AN/TPS–1D is pulsed.

a. When TRIGGER switch S152 is placed in the EXTERNAL position, it selects accurately timed trigger pulses which are generated in the signal comparing system and applies them to blocking oscillator keyer V102A. At the same time, S152 disconnects the +300 volts B+ potential from internal repetition rate multivibrator V101 so that it is inoperative. When placed in the INTERNAL position, S152 applies B+ to V101, allowing it to operate, and disconnects the external triggers from V102A.

b. When operating, internal repetition rate multivibrator V101 generates a rectangular voltage which is differentiated and applied to blocking oscillator keyer V102A.

c. Blocking oscillator keyer V102A accepts either negative trigger pulses from the external

source or positive trigger pulses from the internal repetition rate multivibrator. It produces an output which triggers blocking oscillator V1101A.

d. Blocking oscillator V1101A produces narrow negative pulses that are applied to diode clipper V1102A from the plate circuit of V1101A. At the same time, positive trigger pulses are taken from the cathode circuit of V1101A and applied to IFF PRE-TRIGGER jack J157.

e. Diode clipper V1102A is connected to pass negative pulses to the delay line network. It prevents the positive going portion of the output from V1101A from triggering blocking oscillator keyer V1101B.

f. Delay line Z1101 is a shorted end artificial transmission line which is used to obtain either 12.4 or 37 microseconds of delay between the time when blocking oscillators V1101A and V102B are triggered. The negative pulse which is applied to Z1101 from V1102A travels down the artificial transmission line and is reflected when it reaches the short-circuited end. The polarity of the pulse is reversed when it is reflected. The resulting delayed positive output from the delay line is applied to blocking oscillator keyer V1101B. Delay line discharge diode V1101B conducts only when the delay line is discharging. It terminates the line properly and prevents reflections.

g. Blocking oscillator keyer V1101B amplifies the output positive pulse from the delay line and triggers blocking oscillator V102B. When triggered, V102B generates a high amplitude positive pulse which is coupled to cathode follower V103.

h. Cathode follower V103 is a power-amplifier stage. Its positive output triggers thyratron keyer tube V156 in the keyer circuits.

54. Keyer Circuits
(fig. 40)

The keyer circuits produce a high-voltage pulse 2 microseconds in duration each time the thyratron keyer tube is triggered by the trigger circuit. The keyer circuits employ a dc series-resonant charging circuit to charge a pulse-forming network. The pulse-forming network is then discharged through thyratron keyer tube V156, forming the large negative pulse which is applied to the magnetron in the RF oscillator circuits.

a. High voltage (+5 kv) is applied to pulse-forming network Z161 through charging choke L151 and charging diodes V153 and V154. Charging choke L151 makes it possible to charge the pulse-forming network to almost twice the high-voltage power supply output voltage. Charging diodes V153 and V154 are parallel-connected to handle the charging current. They are in series with the charging choke and pulse-forming network. They conduct during the charge of Z161 and then stop conducting so that Z161 is isolated from the charging voltage source. The result is that when the RADIATE switch is pressed, the pulse-forming network is charged to almost 10 kv and remains charged.

b. When a positive trigger pulse is applied from the trigger circuit to thyratron keyer tube V156, the thyratron provides a low resistance path for the discharge of Z161, and the pulse-forming network discharges through the primary winding of pulse transformer T502 and the thyratron. With Z161 discharging through an impedance slightly lower than its own characteristic impedance, a negative pulse slightly less than 5 kv and exactly 2 microseconds in width is developed across the primary of the pulse transformer during the discharge of the pulse-forming network. After discharging, the pulse forming network is recharged by the high-voltage power supply and the charging choke and remains charged until the thyratron is triggered again approximately 2,500 microseconds later.

c. Shunt diode V155 operates as a negative clamper and prevents a voltage from building up across the pulse-forming network which would be opposite to the initial charge on the network. The shunt diode conducts at the end of each 2 microsecond discharge interval. The conduction of the shunt diode provides the operating current through one coil of protective relay K151 which removes power from the keyer circuits under abnormal conditions.

55. RF Oscillator Circuits
(fig. 40)

The RF oscillator circuits are keyed into os-

cillation by the keyer circuits and they produce RF oscillations which are then applied to the RF transmission line in the RF system.

a. Pulse transformer T502 steps up the negative pulse developed across its primary, but does not invert the polarity of the pulse, so that a negative pulse approximately 28.5 kv is applied to magnetron V502.

b. The magnetron is the RF oscillator. A strong permanent magnet around the magnetron establishes a magnetic field through the tube. When the negative pulse from the pulse transformer is applied to the magnetron it oscillates during the application of the pulse (2 microseconds). These oscillations are applied to the RF transmission line and carried to the antenna which radiates the RF energy.

c. Meter circuit M502 provides for low level monitoring of the average magnetron current which is a relative indication of output power.

Section IV. RF SYSTEM

56. General
(fig. 40)

The RF system conducts the high-power RF pulses from the magnetron oscillator in the transmitting system to the antenna which radiates the RF energy in a narrow beam. The target echoes are picked up by the antenna and are conducted through the RF system to the receiving system input circuits. The RF system also incorporates transmit-receive components that make it possible to transmit and receive by using the same antenna. The tr components prevent the high-power RF pulses from the transmitting system from entering the receiving system where they could cause damage to the signal mixer, and other receiving system input circuits.

a. There are two signal outputs from the RF system. A small portion of the transmitted signal is coupled to the coho channel in the receiving system as a reference signal for mti operation. All of the returning RF echo signals from targets are applied to the signal channel in the receiving system.

b. Test signals which simulate the transmitted signal may be taken from the directional coupler in the RF system, or signals which simulate returning echoes may be applied to the directional coupler in the RF system for troubleshooting and adjustment.

57. Duplexer
(fig. 40)

The duplexer assembly provides protection for the receiving system during the transmission of high-power RF pulses and makes it possible to use the same antenna for transmitting and receiving.

a. The duplexer assembly consists of two tr tubes (V503 and V504) which act as switches. When the magnetron oscillates, the high-power RF energy causes the tr tubes to ionize and this ionization results in the transmitted energy traveling down RF501 toward the antenna rather than entering the signal channel of the receiving system. This is necessary because the sensitive signal mixer and receiving system input circuits would be damaged by the high-power energy from the magnetron if any appreciable amount of this energy were allowed to reach the signal mixer. After the magnetron stops oscillating, the tr tubes deionize and because the relatively weak retuning echo signals do not cause ionization of the tr tubes, the retuning echo signals are conducted through the tr tubes and to the signal mixer in the receiving system.

b. The keep-alive rectifier (V501) is a conventional half-wave negative rectifier which furnishes approximately —800 volts to tr tube V504. This negative potential decreases the ionization time of V504 so that it can more rapidly limit the amount of transmitted energy that enters the receiving system.

c. Shutter gate relay K501 actuates a shutter gate in the cavity in which V504 is located. This gate is closed when the equipment is turned off to prevent the signal mixer crystal from being damaged by transmissions from other nearby equipments while there is no keep-alive voltage. When the equipment is turned on and keep-alive voltage is developed, K501 energizes and the gate is opened so that input signals can be applied to the receiving system.

58. RF Transmission Line
(fig. 40)

The high-power RF pulses from the transmit-

ting system are conducted through a rigid coaxial assembly and interconnecting sections of coaxial transmission line to the antenna. The RF transmission line also conducts the returning echo signals from the antenna to the receiving system.

a. RF transmission line assembly RF501 is a section of rigid coaxial line. The pulsed RF output from the magnetron is coupled into it and the energy propagated along the line toward the antenna. Some of the energy couples into the duplexer, the directional coupler, and the coho mixer assembly.

b. The duplexer prevents any appreciable amount of RF energy from entering the receiving system during transmitting time.

c. The directional coupler accepts a fractional part of the transmitted pulse and makes it available at RF TEST jack J501.

d. A small portion of the transmitted signal is also coupled through an aperture to the coho mixer assembly in the receiving system. This signal is used to phase-lock the coherent oscillator in the receiving system in order to make it possible to cancel the returns from fixed targets.

e. Most of the RF energy from the magnetron is conducted through rigid coaxial section RF855, flexible coaxial cable RF854, rigid coaxial section RF751, rigid coaxial rotating joint section RF752, rigid coaxial section RF856, and rigid coaxial section RF754 to the horn radiator at the antenna.

f. RF signals from the associated iff equipment are applied to iff RF input jack J756 and conducted through the rotating joint section to iff RF output jack J851.

g. The rotating joint section provides for the transmission of both radar and iff signals to the antenna and at the same time rotates the antenna continuously.

59. Antenna Assembly
(fig. 40)

The antenna assembly focuses the transmitted RF energy into a narrow beam and radiates the beam into space. The narrow beam extends the coverage of the equipment and at the same time makes azimuth measurement possible. The returning echo signals that strike the antenna reflector are focused into the horn assembly from which they are conducted to the input of the receiving system by the RF transmission line.

a. Transmitted RF energy conducted by the transmission line is applied to a short radiating element in the waveguide section. The waveguide feeds the horn radiator which directs the energy into the antenna reflector. The antenna reflector focuses the transmitted waves back in the direction of the horn radiator and into space. Echo signals returned from targets strike the antenna reflector and are focused into the horn by the reflector. The echo signals are conducted back to RF501 by the RF transmission line. Once delivered to RF501, the relatively weak echoes are accepted by the duplexer and applied to the input circuits of the receiving system.

b. The iff transmitted signal is conducted from rigid coaxial section RF856 through flexible coaxial cable W850 to the iff antenna which is a dipole with reflecting elements in the mount of the horn radiator. The iff antenna transmits and receives in the same direction as the radar signals, because it rotates with the horn radiator and directs its energy into the same antenna reflector.

Section V. RECEIVING SYSTEM

60. General
(fig. 40)

The relatively weak echo signals returned from targets are applied to the receiving system from the RF system. The receiving system amplifies the weak RF signals, demodulates them, and applies video pulses of usable amplitude to the signal comparing system.

a. Attenuated transmitted pulses are applied from the RF system to the coho channel in the receiving system. These pulses are used to phase-lock the coherent oscillator (coho) with respect to the transmitted signal. The coho signal is used as a reference signal so that the receiving system can respond differently to the returns from stationary and moving targets to provide moving-target information.

b. The receiving system employs the super-

heterodyne principle. A 60-mc difference frequency between the local oscillator (V505) frequency and the returning echo signals is applied to the signal channel and a 60-mc difference frequency between the coho reference signal frequency and the local oscillator frequency is applied to the coho channel. Both channels of the receiving system operate at an intermediate frequency of 60 mc, which can be amplified more efficiently than the radio frequency.

c. Local oscillator V505 is a stable cw oscillator. Its frequency is adjusted to 60 mc higher than the magnetron frequency by means of tuning motor B502. The tuning motor is in turn controlled by L. O. MOTOR switch S613A on the front panel of the indicator.

d. The type of video output signal produced by the receiving system depends upon the mode of operation employed. In the mti mode of operation, mti video (bipolar video pulses) is applied to the 9-mc carrier channel in the signal comparing system. In the normal mode, the coho is disabled and normal video (negative video pulses) is applied to the video circuits in the signal comparing system.

61. Signal Channel
(fig. 40)

Received RF echo signals from the RF system and the cw local oscillator signal are applied through local oscillator injector RF503A and harmonic filter Z509 to signal mixer CR503. The local oscillator injector provides a means of adjusting the strength of the local oscillator signal that is applied to the signal mixer. The harmonic filter permits the RF signal frequencies to pass with very little attenuation but attenuates harmonics of the local oscillator and magnetron frequencies.

a. The signal mixer is a 1N21C type, low-noise silicon crystal diode rectifier. The signal mixer is the first detector of the receiving system. It detects the 60-mc difference frequency between the echo signals and the local oscillator frequency so that all information carried by the RF carrier is transferred to the lower 60-mc IF carrier frequency which can be amplified more easily.

b. The signal IF preamplifiers (V232, V224, and V225) are physically close to the signal mixer in the receiver-transmitter unit. They amplify the weak 60-mc IF signal in a special low-noise input circuit before the signals are carried by a relatively long coaxial cable to 60-mc IF amplifier Z301 in the signal comparator unit.

c. The first three signal IF amplifiers (V301 through V303) are conventional IF amplifiers. The gain of the first and third IF amplifiers is controlled by a manual gain potentiometer so that the overall gain of the receiving system can be varied. The last three IF amplifiers (V304 through V306) operate as limiter amplifiers so that pulse-to-pulse variations in the returns from stationary targets are minimized.

d. All the signal IF amplifiers amplify the 60-mc IF carrier signal to a level at which efficient detection or demodulation of the signal can be accomplished. The amplified IF signal is applied to the phase detector (par. 63), which operates as the second detector of the receiving system and applies video pulses representing targets to the signal comparing system.

62. Coho Channel
(fig. 40)

The coho channel provides a reference signal (its phase being dependent upon the phase of the transmitted signal) to the phase detector so that the receiving system can respond differently to the returns from stationary and moving targets and provide moving-target information. Attenuated pulses of the transmitted RF signal from the RF system and the cw local oscillator signal are applied to coho mixer CR502.

a. The coho mixer is a 1N21B type, silicon crystaldiode rectifier. It operates the same as the signal mixer except that signal-to-noise ratio does not present a problem as it does in the signal channel because the coho rf input signal is considerably stronger than the RH echo signals. The 60-mc output from the coho mixer is applied to the coho IF preamplifier (V506) which is a conventional one-stage IF amplifier which boosts the coho signal before it is carried through a relatively long length of coaxial cable to coherent oscillator V350 in the signal comparator unit.

b. Coho IF amplifiers V350 through 352 amplify the input from the coho IF preamplifier to

a level which can synchronize the coho (V353). The coho is a cw, 60-mc oscillator which is synchronized or phase-locked by the amplified reference signal from the coho mixer. The output from the coho is then amplified by coho amplifier V354 and applied to the phase detector as a reference signal with a fixed phase relationship with respect to the transmitted RF signal.

63. Phase Detector
(fig. 40)

The phase detector consists of two 1N70 type, germanium crystal diode rectifiers (CR301 and CR302). The operation of the phase detector depends upon the mode of operation of the equipment.

a. In the normal mode of operation, the coho is disabled and there is no input to the phase detector from the coho channel. In this case, CR301 operates as a conventional second detector circuit and negative video pulses are applied from CR301 to normal video limiter V3306 in the video circuits of the signal comparing system.

b. In the coho adjust mode, the coho oscillator is not disabled and the coho and 60-mc IF signals from the signal channel are applied to the phase detector. In this mode, bipolar video (with the negative video pulses greater in amplitude than the positive video pulses) is applied from CR301 to normal video limiter V3306 in the signal comparing system to make adjustments in the coho channel. The coho adjust mode is never used to detect targets.

c. In the mti mode, both inputs are applied to the phase detector and both crystal diodes are used in a true phase detector circuit. In this mode, the phase detector compares the phases of the signal and coho inputs and produces bipolar video pulses with amplitudes and polarities which depend upon the relative phase of the two input signals. The output from the phase detector is the resultant signal developed across both crystal diodes and the output in this mode makes cancellation of the returns from stationary targets possible in the signal comparing system. Cancellation of the returns from stationary targets is possible because they cause the phase detector output from pulse to pulse. However, there is no cancellation of returns from a moving target because the change in slant range causes changing outputs from the phase detector from pulse to pulse. In the mti mode bipolar video pulses are applied from the phase detector to the 9-mc carrier channel in the signal comparing system.

d. Noise level amplifier V307 amplifies the noise produced by the signal channel and applies it to TEST METER M2350 when TEST SELECTOR switch S2353 is in the I.F. AMPL. LEVEL position and the equipment is in the normal mode of operation. This test provides for a means of checking the overall gain of the receiving system and adjusting the gain of the 60-mc IF amplifier to make the over-all gain of the receiving system correct by red-lining the meter.

Section VI. SIGNAL COMPARING SYSTEM

64. General
(fig. 40)

Video pulses representing both fixed and moving targets are applied to the signal comparing system from the phase detector in the receiving system. The signal comparing system cancels the returns from fixed targets in the mti mode of operation so that only video pulses representing moving targets are applied to the indicating system.

a. Cancellation of the returns from fixed targets is accomplished by circuitry that delays the echoes from a transmitted pulse and compares them with the echoes from the following transmitted pulse. The echo pulses from the first transmitted pulse are delayed for a length of time equal to the pulse-repetition time of the equipment. Then inverted echo pulses from the following transmitted pulse (which are not delayed) are compared with the delayed pulses so that the returns from fixed targets cancel and the returns from moving targets do not. Cancellation of fixed-target signals is possible because the returns from a fixed target (from the same target but from successive transmitted pulses) appear as pulses of equal amplitude and the same polarity in the successive input video

signals to the signal comparing system. The returns from a moving target (from the same target but from successive transmitted pulses) vary in amplitude and polarity in the successive input video signals. This is because the phase of the signals returning from a moving target changes with respect to the transmitted signals and therefore with respect to the coherent input to the phase detector, the coherent signal being phase-locked to the transmitted signal.

b. The signal comparing system establishes the pulse-repetition time of the equipment. To cancel the returns from fixed targets, signal returns from a transmitted pulse must be delayed for the exact time between transmitted pulses before they are used to cancel the signal returns from the following transmitted pulse. This timing requirement is taken care of by having the signal comparing system develop transmitter triggers which depend upon the exact time delay that takes place in the signal comparing system. The transmitter is normally triggered at a time which depends upon the application of negative trigger pulses from trigger amplifier V1352 in the signal comparing system to the trigger circuit in the transmitting system.

c. Normal or mti video (positive video pulses in either case) pulses are applied to the indicating system from video cathode follower V3307. Normal or mti video pulses are applied to the remote ppi indicator from remote video cathode follower V3308.

d. The signal comparing system can be logically broken down into seven subsystems (channels or circuit groups) as follows:

(1) 9-mc carrier channel.
(2) Delay channel.
(3) Nondelay channel.
(4) Video circuits.
(5) Amplitude balancing circuits.
(6) Time balancing circuits.
(7) Trigger generator circuits (pars. 65–71).

e. In the normal mode of operation, negative video pulses from the receiving system (waveform K) are applied to normal video limiter V3306. The video pulses are amplified (the stronger ones being limited) and are then applied as positive video pulses (waveform L) through output cathode followers to the indicating system and the remote ppi.

f. In the mti mode of operation, the video input to the signal comparing system amplitude modulates a gated 9-mc oscillator in the 9-mc carrier channel. (Waveform A represents the pulse returns from one transmitted pulse and waveform C represents the pulse returns from the following transmitted pulse approximately 2,500 microseconds later.)

g. The output from the 9-mc carrier channel is applied to the delay and nondelay channels (waveform B from one transmitted pulse and waveform D from the following transmitted pulse). The input of the delay channel (waveform B) is delayed by the delay channel and becomes waveform F for comparison. The input to the nondelay channel (waveform D) is not delayed by the nondelay channel and becomes waveform E for comparison. The output from the delay channel is a negative envelope which results from demodulating the 9-mc carrier. It consists of the video information (waveform A) riding on a negative dc level which depends upon the peak amplitude of the alternations of the 9-mc carrier output from the delay amplifier. The output from the nondelay channel is a positive envelope which results from demodulating the 9-mc carrier. It consists of the video information (waveform C) riding on a positive dc level which depends upon the peak amplitude of alternations of the 9-mc carrier output from the nondelay amplifier.

h. The negative envelope from the delay channel (waveform F) which contains video information from waveform A is compared with the positive envelope from the nondelay channel (waveform E) which contains information from waveform C so that the algebraic sum of the two signals is developed at the comparison point. Since the fixed-target returns are equal in amplitude and opposite in polarity they cancel and do not appear in the outputs to the indicating system. The carrier envelopes (dc components) also cancel because they are equal in amplitude and opposite in polarity. The echo pulses from moving targets do not cancel because they are not necessarily equal in amplitude or opposite in polarity; the amplitude and polarity depend upon the velocity of the moving target toward the radar set. The moving-target signals are amplified and polarized by the video

circuits and are applied to the indicating system and the remote ppi unit as positive video pulses.

i. To obtain maximum cancellation of clutter signals, the fixed-target pulse outputs from the delay channel and nondelay channel must have essentially the same amplitude and must appear simultaneously at the comparison point. The amplitude requirement for cancellation is taken care of by the amplitude balancing circuits and the time requirement is taken care of by the time balancing circuits.

j. In the mti mode the time between transmitted pulses depends upon the amount of time delay in a trigger loop within the signal comparing system. This is accomplished by synchronizing a free-running multivibrator that gates the 9-mc carrier oscillator in the 9-mc carrier channel. The multivibrator also gates the trigger generator circuit which produces negative pulses and applies them to the transmitting system.

k. The seven subsystems of the signal comparing system are discussed in paragraphs 65 through 71.

65. Carrier Channel, 9-Mc
(fig. 40)

The 9-mc carrier channel provides a carrier frequency upon which the input video pulses can be carried most efficiently through the mercury delay line. The 9-mc frequency is used to obtain the required amplitude and bandwidth through the delay line.

a. A pentagrid-type tube is used as a gated 9-mc carrier oscillator (V1355) to develop triggers by using the delay line as a timing device. It oscillates during the time that the V1354 half of the carrier gate multivibrator is beyond cutoff (waveform T). The 9-mc oscillations occur from 10 microseconds before the transmitter fires (to prevent the returning echo pulses from effecting the timing of the transmitter triggers) until approximately 2,140 microseconds after the transmitter fires (waveform V). The oscillations are interrupted in order to use the envelope of the demodulated 9-mc oscillations for timing.

b. Video pulses from the receiving system (waveforms A and C) are applied to V1355 so that the pulses amplitude modulate the 9-mc carrier. The modulated carrier is amplified by 9-mc amplifier V1356 and by 9-mc output amplifier V1357 (waveforms B and D) before being applied to the delay and nondelay channels. The output signal of V1357 is applied directly to the delay line in the delay channel. The same output signal is applied to the nondelay amplifier but it is attenuated approximately 60 db so that the signal input voltages to the delay and nondelay amplifiers are more nearly equal.

c. The carrier gate multivibrator is a free-running multivibrator which is adjusted to have a natural frequency slightly lower than the pulse-repetition frequency of the equipment (natural period that is longer than the pulse-repetition time or pulse interval of the equipment). The multivibrator is synchronized by trigger pulses obtained from a trigger loop within the signal comparing system. The trigger loop consists of the carrier gate multivibrator, the 9-mc oscillator, the 9-mc amplifiers, the delay channel (except for the 1.9-microsecond delay line), and the time balancing circuits which adjust the amount of delay of the trigger pulses that synchronize the carrier gate multivibrator. In effect, the carrier gate multivibrator synchronizes itself through the trigger loop so that its period is equal to the sum of all the delays in the trigger loop (slightly more than 2,500 microseconds).

d. An output is also taken from the V1353B half of the carrier gate multivibrator (waveform W) and applied to the trigger generator. The trigger generator develops negative triggers, which occur 10 microseconds after the 9-mc oscillations begin, and applies them to the transmitting system. These triggers time the start of the transmitted pulses.

66. Delay Channel
(fig. 40)

The delay channel delays, amplifies, and demodulates the modulated 9-mc carrier and applies video pulses to the comparison point network in the video circuits.

a. The input modulated 9-mc carrier (waveform B) is delayed 2,500 microseconds by mercury delay line W2350 so that the negative output envelope from the delay channel can be compared with the positive output envelope from the nondelay channel. A 9-mc carrier frequency

is used because the delay line operates most efficiently at this frequency. Because the delay line attenuates the signal voltage approximately 60 db, amplifiers V1301 through V1305 are necessary to raise the level of the 9-mc signals so that efficient detection can be accomplished by delay amplifier detector V1306.

b. The gain of delay amplifiers V1301 through V1304 is controlled automatically by an amplitude balancing bias from the amplitude balancing circuits so that the amplitude of the output negative envelope from the delay channel (waveform F) is equal to the amplitude of the output positive envelope from the nondelay channel (waveform E).

c. The output from delay amplifier detector V1306 is applied to two circuits. The negative envelope which results from demodulating the modulated 9-mc carrier (waveform N) is part of the trigger loop signal. The negative envelope is also applied to the comparison point (waveform F) through 1.9 microsecond delay line W2351. The 1.9-microsecond delay line is necessary to compensate for the inherent time delays which affect the timing of waveform E which is compared with waveform F at the comparison point. These inherent time delays are the delays in the trigger loop (outside of the delay channel) and the delays in the nondelay channel. Time balance between waveforms E and F is accomplished by delaying F an additional 1.9 microseconds and then adjusting the time delay of the time balancing circuits so that the total of all the delays affecting waveform E is equal to 1.9 microseconds.

67. Nondelay Channel
(fig. 40)

The nondelay channel attenuates, amplifies, and demodulates the modulated 9-mc carrier and applies video pulses to the comparison point network in the video circuits. The nondelay channel is identical with the delay channel except that it contains no delay lines, its gain is not controlled automatically, its detector is a positive detector rather than a negative detector, and the input signal is attenuated to compensate for the attenuation of the delay line in the delay channel.

a. The nondelay amplifier attenuates and amplifies the modulated 9-mc carrier signal (waveform D) so that the output signal (waveform E) is a positive envelope equal in amplitude and in time balance with the negative envelope from the delay channel (waveform F). This is done so that the returns from fixed targets cancel across the comparison point components and only moving targets are passed on to the video circuits.

b. The nondelay channel is the only subsystem in the signal comparing system which cannot affect the operation of the equipment in the normal mode of operation of the equipment. The nondelay channel is used only when the equipment is in the mti mode.

68. Video Circuits
(fig. 40)

The video circuits limit and amplify signals in all modes of operation of the equipment. Video information is applied from the video circuits to the indicating system and to the remote ppi unit.

a. In the normal mode, negative pulses from either fixed or moving targets are applied to normal video limiter V3306 from the phase detector in the receiving system (waveform K), the phase detector operating as a conventional second detector in the normal mode. The screen and plate circuits of V3306 are common to the screen and plate circuits of mti video limiter V3305 so that either normal or mti video can appear in the common plate circuit. A relay actuated by a mode selector switch disables either V3305 or V3306 depending upon the mode of operation selected. Normal video signals are amplified and inverted by V3306 and mti video signals are amplified and inverted by V3305. Strong video signals cause limiting in the common plate circuits of V3305 and V3306.

b. The input to video cathode follower V3307 is either normal video (waveform L) or mti video (waveform J), depending upon the mode of operation. The cathode-follower stage acts as a power amplifier and matches the low impedance of the coaxial cable which carries the positive video information (waveform L or J) to the indicating system. Video cathode follower V3308 does the same for video sent to the remote ppi unit.

c. In the mti mode, a positive envelope (waveform E) is applied to the comparison point from

the nondelay channel and a negative envelope is applied from the delay channel. With proper operation of the signal comparing system, the envelopes which result from demodulating the 9-mc carrier cancel, and the positive and negative fixed clutter targets cancel (waveform G) so that they are not applied to mti video amplifier V3303. Since the returns from moving targets are not necessarily of equal strength and opposite polarity when applied to the comparison point, the output pulses from the comparison point are either positive or negative depending upon the polarity and amplitude of the demodulated video pulses. The bipolar video pulses representing moving targets are amplified by mti video amplifier V3303 and applied to video polarizer V3304 (waveform H).

d. Both positive and negative video pulses are applied to video polarizer V3304, but the operation of the circuit is such that only negative pulses appear in the output signal (waveform I). This polarization is necessary because of the manner in which video information is applied to the ppi scope. If the video pulses remained bipolar, some would cause intensified spots on the ppi screen, but the opposite polarity pulse would cause dark areas on the screen and remain undetected.

e. The negative video pulses from V3304 are amplified and limited by mti video limiter V3305 (waveform J) before being applied to cathode followers V3307 and V3308. In the mti mode, the operation of V3305 is the same as it is for V3306 in the normal mode. The cathode followers operate the same in either mode of operation.

f. The output cathode followers are the only stages in the signal comparing system that affect the operation of the equipment in all modes of operation.

69. Amplitude Balancing Circuits (fig. 40)

The amplitude balancing circuits develop a bias voltage which controls the gain of four delay amplifier stages in the delay channel to equalize the output amplitudes from the delay and nondelay channels. The closer the amplitudes are balanced the better is the cancellation of fixed targets.

a. The amplitude balancing circuits are actuated by a difference in the average levels of the signals developed across the comparison points components. They are not affected significantly by the video differences. Amplitude balance dc amplifier V3301, in conjunction with reference tubes V3300 and V3302, operates as a two-stage dc amplifier which has a constant dc in its output circuit when there is no dc applied to the input circuit. The amplitude balance potentiometer (R2354 on the signal comparator or R2627 on the indicator) is adjusted to make the amplitude of the negative envelope from the delay channel essentially equal to the amplitude of the positive envelope from the nondelay channel.

b. When an unbalance in the output levels from the delay and nondelay channels occurs, the comparison point components operate as a sensing device. The dc potential difference between the two output levels is applied to V3301 which amplifies the difference. This amplitude difference is the amplitude balancing bias. It is applied to the delay channel to change the gain of the delay channel and essentially equalizes the output amplitudes of the two channels. Actually, the output amplitudes cannot be perfectly balanced by the circuit. For example, if the emission of fifth nondelay amplifier V2305 falls off slightly during operation of the equipment, the positive average voltage to the comparison point decreases and a net negative dc difference potential (error voltage) is applied to V3301. This dc error voltage is amplified by V3301 and applied to the delay channel as a negative correction bias which decreases the gain of the delay channel until the output amplitude level of the delay channel is reduced to a slightly higher level than the output from the nondelay channel. The slight difference (error voltage) is necessary to *hold* the output of the delay channel lower and essentially equal to the lower output from the nondelay channel which results from the decreased gain of V2305.

70. Time Balancing Circuits (fig. 40)

The time balancing circuits are used to obtain a variable time delay so that the time of the output of the nondelay channel (waveform E) can be made to coincide in time with the output from the delay channel (waveform F) at the comparison point network. This time balance is

necessary to obtain maximum cancellation of fixed targets.

a. Two factors are compensated for by the time balancing circuits. One is that the inherent time delays in the delay and nondelay channels are not necessarily equal. The other is that time delays not common to the delay channel result from the fact that the output of the delay amplifier detector is used to start the timing of the next transmitted pulse.

b. Time balance is accomplished by delaying the output from the delay amplifier detector an additional 1.9 microseconds before it is applied to the comparison point. Then the variable time delay of the time balancing circuits is adjusted so that the total of all the time delays in the time balancing circuits, the 9-mc carrier channel, and the nondelay channel is equal to 1.9 microseconds (the delay of W2351).

c. The carrier gate multivibrator is a free-running multivibrator. When the V1354 half cuts off, 9-mc carrier oscillator V1355 begins to oscillate. These oscillations are amplified by V1356 and V1357, travel down the 2,500-microsecond delay line, and are amplified again by delay amplifiers V1301 through V1305. The negative envelope of the 9-mc oscillations is detected by delay amplifier detector V1306 so that the time of the start of the negative gate from V3306 (waveform N) corresponds to 2,500 microseconds after the 9-mc oscillations begin (plus any small inherent time delays picked up in the 9-mc carrier channel and the delay channel). The demodulated negative envelope (waveform N) input to the time balancing circuits is differentiated (waveform 0) and applied to slope generator V1350. The operation of V1350 is similar to that of a sweep generator. The input cuts off the stage and a capacitor in the plate circuit charges while the tube is beyond cutoff. This action produces a short rise in voltage at the output (waveform P) which is in turn differentiated (waveform Q) and applied to pick-off amplifier V1351. The cathode of V1351 returns to a voltage-divider so that mti balance potentiometer R2356 (or R2618 on the indicator) controls when V1351 goes into conduction. A small time delay (from 1 to 3 microseconds) is obtained by operating V1351 beyond cutoff so that the start of the input signal to the grid (waveform Q) does not cause conduction. The setting of R2618 establishes the time balancing bias which controls the time of conduction of V1351. When V1351 conducts, a negative trigger is developed and applied to the V1354 half of the carrier gate multivibrator (waveform S). Approximately 350 microseconds previous to the development of the negative trigger, the natural timing of the multivibrator causes the V1354 half of the multivibrator to go back into conduction (waveform T) so that the negative trigger causes the V1354 half to go back into cutoff before it would naturally do so. The loop of the signal path from the time that the V1354 half of the carrier gate multivibrator cuts off until it cuts off again is called the trigger loop. This trigger loop establishes the overall timing of the carrier gate multivibrator and therefore the time between transmitter pulses.

d. By providing a variable time delay in the portion of the trigger loop which is not common to the delay channel, the time balancing circuits make it possible to adjust the output from the nondelay channel so that it is in time balance with the output from the delay channel. This occurs when R2356 (or R2618) is adjusted so that all of the time delays affecting the timing of the output from the nondelay channel are equal to 1.9 microseconds, the time delay of W2351.

71. Trigger Generator Circuits (fig. 40)

The trigger generator circuits produce negative pulses which depend upon the timing of the trigger loop and apply them to the transmitting system as external transmitter triggers. The output triggers (waveform Z) take place 10 microseconds after the 9-mc carrier oscillator starts to oscillate. This 10-microsecond time delay allows time for the 9-mc oscillation to stabilize before the video pulses start arriving and also insures that the carrier gate is triggered by the leading edge of the delayed carrier gate with no influence from received signals.

a. Trigger generator V1353A is a shock-excited oscillator which is gated by the output from the V1353B half of the carrier gate multivibrator (waveform W). The trigger generator produces a critically damped sine wave (waveform X) which has a period of 20 microseconds.

The first positive swing in voltage causes an output from trigger amplifier V1352. Because a bias network in its cathode circuit then holds the stage sufficiently beyond cutoff (waveform Y), the second and subsequent positive alternations do not raise the tube above cutoff.

b. The leading edge of the first positive alternation from the trigger generator causes a negative pulse to be developed in the output circuit (waveform Z). The output negative triggers appear 10 microseconds after the start of the negative gate input to V1353A because the first negative (10-microsecond duration) alternation does not affect the operation of trigger amplifier V1352. The output negative triggers are applied to the transmitting system as transmitter triggers in the mti mode of operation. In the normal (external trigger) mode of operation, the output negative triggers also determine the time that the transmitter fires. This is automatically the cause when the OPERATION selector switch on the indicator unit is changed from the MTI to the NORMAL position unless an additional switch is thrown so that the transmitter is triggered internally.

Section VII. INDICATING SYSTEM

72. General
(fig. 40)

The indicating system displays video pulses which represent the positions of targets on a 7-inch ppi scope and a 5-inch A scope. The ppi scope displays range and azimuth. Either 5- or 25-mile range markers appear as concentric circles for measuring range. A radial sweep, which can be seen through a transparent scale calibrated in degrees of azimuth or mils, indicates azimuth as it is made to follow the rotation of the antenna. The A scope displays slant range of targets along a particular azimuth. It is used to obtain better range resolution on targets which are detected on the ppi scope and it is also used in making equipment adjustments.

a. Each scope has its own gating, sweep circuits, and range selector switch. The ranges are 20, 40, 80, and 160 nautical miles. The A-scope range selector switch has an additional position which makes it possible to view any expanded 10-mile segment of range starting from approximately 15 miles to 150 miles. The position of the range strobe, which is seen on the ppi scope, determines the start of the 10-mile expanded sweep which appears on the A scope.

b. The indicating system can function only when the RADIATE switch is in the ON position because the indicator trigger is obtained from pulse transformer T502 in the transmitting system. Without the indicator trigger, both scopes are blank because no trigger is applied to the sweep and unblanking circuits.

c. In addition to the indicator trigger, the only other signal inputs into the indicating system are positive video pulses from the signal comparing system and positive iff video pulses from the associated iff equipment. There are no outputs from the indicating system.

d. The indicating system can be logically broken down into six subsystems or circuit ground as follows:

(1) Ppi sweep and display circuits.
(2) Fixed range marker circuits.
(3) Range strobe generator.
(4) A-scope sweep and display circuits.
(5) Video circuits.
(6) Indicator high-voltage power supply (pars. 73–78).

73. Ppi Sweep and Display Circuits
(fig. 40)

The ppi sweep and display circuits generate and display an intensified radial sweep which extends from the center of the ppi screen outward. They also display fixed range markers, the variable stroke marker, radar video, and iff video information, all of which are applied from other circuits in the indicating system.

a. To have the ppi sweep move linearly from the axis of the tube (when the transmitter fires) to the outer edge of the screen (at a time dependent upon the setting of the PPI RANGE SELECTOR switch), the ppi sweep circuits generate a sweep voltage which causes a linear change in current through the deflection coil. This linear change in current causes the strength of the magnetic field about the deflection coil to increase linearly and thus deflect the beam linearly. This sweep provides a linear time base

upon which video and range marker information are displayed. As the antenna is rotated, the antenna drive motor also drives a synchro transmitter. Stator information is not from the antenna positioning system to the indicating system. Synchro receiver B602 in the indicating system drives the deflection coil so that the ppi sweep always indicates the azimuth to which the antenna is pointing.

b. Ppi gate multivibrator V603 is triggered by the indicator trigger. It provides a negative gate to sweep generator V605 while it provides a positive gate to the control grid of the ppi scope to allow beam current to flow. The time duration of the gate is 20, 40, 80, or 160 miles, depending on the position of the PPI RANGE SELECTOR switch. Ppi gate clamper V604A permits the application of bias to the multivibrator while disconnecting a bias network so that it will not affect the timing of the multivibrator.

c. Ppi sweep generator V605 produces a positive sawtooth voltage which is amplified by sections A and B of sweep voltage amplifier V606. Since changes in *current* are necessary to deflect the beam, ppi sweep power amplifier V608 provides the necessary deflection coil current. Feedback from V608 to V606A makes the deflection coil current through V608 and the deflection coil uniformly proportional to the input sawtooth voltage to V606A by converting this voltage to a trapezoidal-type sweep voltage. This type of sweep voltage causes a linear change in current through the deflection coil. Ppi sweep clamper V607A insures that the sweep starts at the same point on the screen regardless of the sweep range being used.

d. Ppi focus current regulator V610 utilizes the constant-current characteristics of a pentode to maintain focus current constant. This is necessary because focus current is supplied by an unregulated +450-dc supply voltage.

74. Fixed Range Marker Circuit (fig. 40)

The fixed range marker circuits generate range markers for both the ppi and the A scope. Normally, 5-mile range markers are displayed on the 20- and 40-mile sweep ranges, and 25-mile range markers on the 80- and 160-mile sweep ranges. A soldered link connection may be changed to provide 10-mile range markers on all sweep ranges instead of 5- and 25-mile markers.

a. Marker gate multivibrator V614 is triggered by the indicator trigger. Its negative going output shock-excites 16-kc gated oscillator V615. The oscillator produces a slightly damped continuous 16-kc sine wave as long as the output from V614 is negative (slightly more than 160 miles). When the output of V614 swings positive, the sine wave oscillations are quickly damped out. The first negative swing of the 16-kc oscillation corresponds to the time of the indicator trigger which in turn corresponds to the time when the transmitter fires. The negative swings occur every 61 microseconds which corresponds to 10,000 yards or approximately 5 nautical miles of radar range.

b. Limiter peaker V616A employs grid limiting and cut off limiting to produce sharp positive pulses with leading edges which correspond to 0, 5, 10, 15, (etc.) miles of radar range. The sharp positive leading edges are applied to 5-mile blocking oscillator keyer V616B and appear at the grid of 5-mile blocking oscillator V617A to trip this biased single-swing blocking oscillator every 5 miles. The output wave form shown for V616B is determined principally by reflections back from the blocking oscillator transformer associated with V617A.

c. Two microseconds wide negative pulses are taken from the plate circuit of V617A in the 20 and 40 positions of PPI RANGE SELECTOR switch S606, amplified by ppi video-marker mixer V602 and applied to the cathode of ppi scope V609. On the screen they appear as intensified concentric circles every 5 miles.

d. Narrow positive pulses are taken from the cathode circuit of V617A in the 20, 40, and EXP positions of A RANGE SELECTOR switch S609. They are amplified by A video-marker mixer V619 and A video amplifier V612B and applied to the vertical upper deflection plate of the A scope to produce sharp positive 5-mile range markers.

e. Narrow positive pulses are also taken from the cathode circuit of V617A and applied through 25-mile blocking oscillator keyer V617B to the grid of 25-mile blocking oscillator V618B so that every fifth positive pulse triggers V618B. The output waveform shown for V617B results

from the action of V618B. Marker clamper V618A permits the application of bias to the grid of V618B without affecting the timing of the stage. When the range selector switches are in the 80 or 160 mile positions, 25-mile range marks are taken from V618B and applied to the scopes the same as the 5-mile markers are applied.

75. Range Strobe Generator (fig. 40)

The range strobe generator is triggered by the indicator trigger. It produces a variable time delay and applies a delayed trigger to the ppi scope which displays it as the range strobe and at the same time applies a trigger to the A-scope sweep circuits to start the expanded sweep.

a. Range strobe multivibrator V621 is triggered by the indicator trigger. Its output is a negative-going gate which starts when the transmitter fires and ends at a time which depends upon the setting of the RANGE STROBE control on the front panel of the indicator unit. As this control is varied, the timing of the multivibrator is affected so that the trailing edge of the negative gate is varied. The output of V621 passes through a differentiator consisting of R686 and C646 so that the trailing edge of the negative gate becomes a positive trigger pulse. This pulse is applied to a strobe blocking oscillator keyer V613A which in turn triggers strobe blocking oscillator V613B. The output of V613B is a narrow negative going pulse which is amplified by iff video-strobe mixer V601, and appears as a negative pulse at the cathode of the ppi scope. This produces an intensified spot on the ppi screen which indicates the position of the strobe.

b. When A RANGE SELECTOR switch S609A is in the EXP position, the positive trigger from the differentiator (R686 and C646) also triggers A gate multivibrator V622. In this case, the outputs of V622 are a negative 10-mile gate to sweep generator V623 and a positive 10-mile unblanking gate to the control grid of the A scope to allow beam current to flow during sweep time. The 10-mile sweep voltage produced by V623 is amplified by V624 and applied to the deflection plates of the A scope to produce an expended time base.

76. A-Scope Sweep and Display Circuits (fig. 40)

The A-scope sweep and display circuits produce horizontal sweeps or time bases on the A scope and display radar video and fixed range markers on the A scope.

a. The A scope differs from the ppi scope in the manner in which information is displayed. The A scope utilizes position (or deflection) modulation, while the ppi scope utilizes intensity (or grid) modulation. Another significant difference is that to obtain a sweep, the A scope uses electrostatic deflection which requires sawtooth voltages applied to deflection plates, while the ppi scope uses magnetic deflection which requires a sawtooth of *current* through the deflection coil. As in the case with the ppi scope, the beam current is held beyond cutoff until an unblanking gate allows beam current to flow.

b. Stages V622 through V625 and V604B generate a horizontal sweep which appears on the screen. A-gate multivibrator V622 is triggered by the indicator trigger when A RANGE SELECTOR switch S609A is in the 20-, 40-, 80-, or 160-mile position. The multivibrator produces positive and negative gates of corresponding time durations. A-gate clamper V604B permits the application of bias to V622 while disconnecting the bias network so that it does not affect its timing. The A-scope waveforms are shown for expanded sweep conditions. With S609 in a position other than EXP, the wave forms differ only in that they start at zero time and vary in time duration. The positive output from V622 is applied to the control grid of A scope V625 to unblank it, while the negative output gate is applied to sweep generator V623 to hold it beyond cutoff during the time that the sweep is being formed. The output of V623 is a positive sawtooth voltage which is applied to A-paraphase amplifier V624.

c. A-paraphase amplifier V624 is a cathode-coupled paraphase amplifier (one input produces two outputs). The two outputs are applied to the horizontal deflection plates of A scope V625 to provide the necessary sawtooth voltages to produce a horizontal time base by means of electrostatic deflection.

77. Video Circuits (fig. 40)

The video circuits amplify and mix the in-

formation applied to each scope so that composite video signals of sufficient amplitude are applied to each scope.

a. In all modes of operation of the equipment, positive video pulses are applied from video cathode follower V3307 in the signal comparing system to video amplifier V611 in the indicating system. Video amplifier V611 amplifies the radar video pulses and applies them to video cathode follower V612A. Two outputs are taken from V612A. Positive video pulses go to A video-marker mixer V619. The output of V619 is a composite negative signal consisting of range markers and radar video pulses. A-video amplifier V612B amplifies the composite signal before it is applied to the vertical upper deflection plate of the A scope.

b. Positive radar video pulses are also taken from V612A and are applied to ppi video-marker mixer V602. This stage also receives range markers so that its output is a composite signal. In addition to radar video information and range markers appearing in the output of V602, iff video pulses and the strobe markers are mixed in iff video-strobe mixer V601 and also appear in the composite video signal at the plate of V602. Amplifiers V601 and V602 have a common plate load. In this way, radar video pulses, range markers, iff video pulses, and the range strobe marker all appear at the cathode of the ppi scope as negative pulses which intensity-modulate the beam so that intensified spots appear on the screen to display all four types of information. Ppi video clamper V607B clamps the signals applied to the cathode of the ppi-scope negative so that weak targets following strong ones are not lost.

c. With ANTI JAM switch S607 in the OFF position, the antijam circuit, which consists of C624 and L603 and video negative limiter CR601, has very little effect on the video signals that are coupled from V611 to V612A.

d. When the ANTI JAM switch is in the ON position, the coupling between V611 and V612A becomes a high-pass filter. Any long pulses of jamming or clutter are differentiated so that only the leading edge of the long pulse is reproduced. Crystal diode CR601 removes the negative overshoot that occurs at the trailing edge of the long positive pulse when it is differentiated.

78. Indicator High-Voltage Power Supply
(fig. 40)

Indicator high-voltage rectifier V626 is a half-wave rectifier used to supply necessary high voltages to operate the ppi scope and A scope. Rectifier V626 supplies +5,000 volts dc to the aquadag and +700 volts dc to the first anode of the ppi scope. It also supplies +1,500 volts dc to the second anode (and aquadag) of the A scope as well as various potentials between —1,500 volts dc and ground to the grid, cathode, and first anode circuits of the A scope.

Section VIII. ANTENNA POSITIONING SYSTEM

79. General
(fig. 40)

The antenna positioning system controls the speed and direction of rotation of the antenna through 360° of azimuth. It consists of an antenna rotate control mechanism which controls the speed and direction of the antenna, a servo amplifier which furnishes electrical driving power to the antenna drive motor, and the antenna drive assembly which furnishes the mechanical driving power to rotate the antenna and two synchro transmitters. The synchro transmitters furnish antenna position information to the indicating system and the remote ppi.

a. The antenna may be rotated clockwise or counterclockwise at speeds from 0 to 15 revolutions per minute from the operating position at the indicator unit. Feedback circuits in the servo amplifier are used to stabilize the speed of rotation.

b. Damage to the drive assembly due to temporary or sustained overload conditions is prevented by protective circuits.

80. Antenna Rotate Control Mechanism
(fig. 40)

The antenna rotate control mechanism makes it possible to control antenna rotation from the indicator unit. It is a mechanical mechanism consisting of a hand wheel which actuates gears, cams, microswitches, and a potentiometer. These

components are arranged so that a variable dc potential from the potentiometer controls the speed of antenna rotation and the positions of the cams and microswitches control the direction of rotation.

a. The ANTENNA ROTATE hand wheel turns antenna rotate control potentiometer R609 from which a dc potentiometer is obtained which depends upon how far the hand wheel is turned from its center position. This dc potential is applied to control tube V703A in the servo amplifier to control the speed of rotation of the antenna.

b. The ANTENNA ROTATE hand wheel also actuates cams and microswitches which control motor control relays K701 and K702. By controlling the direction of current flow through the armature of antenna drive motor B751, these relays control the direction of rotation of the motor and therefore the direction of rotation of the antenna. The cams and relays also protect the antenna drive assembly from damage due to rapid reversal of the ANTENNA ROTATE hand wheel by providing dynamic breaking of the drive motor when the hand wheel is passed through zero.

81. Servo Amplifier
(fig. 40)

The servo amplifier furnishes direct currents necessary to rotate the armature of antenna drive motor B751 to permit control of the speed and direction of rotation of the motor.

a. Bridge rectifier CR701 converts input 115-volt, 400-cycle power to +95 volts dc to supply constant field excitation for the drive motor. The speed of rotation of the motor depends upon how much average current flows through the armature and the direction of rotation depends upon the direction of current flow through the armature.

b. Input ac power is applied through transformers T704 and T703 to thyratron control rectifiers V701 and V702. When the control rectifiers are ionized, they conduct and present a very low resistance to the flow of armature current back to the ac source. Because current can only flow through the control rectifiers in one direction, the contacts of K701 are used to reverse the direction of current flow through the armature of the drive motor.

c. Whether or not the control rectifiers conduct and how much they conduct depends on several factors. The ac power input applied through T701 to control tube V703A, the rc integrator networks, and discharge diode V705A develops a bias level which depends on how much control tube V703A conducts. This bias normally prevents the control rectifiers from conducting. When the ANTENNA ROTATE hand wheel is moved from the zero position, a positive dc voltage is applied from antenna rotate control R609 to the cathode of V703A. This voltage decreases the conduction of V703A which in turn decreases the bias level on the control rectifiers so that the ac input applied through T701 overcomes the bias on the control rectifiers and they conduct. The current through the control rectifiers flow through the armature of B751 and the drive motor rotates. If the hand wheel is moved farther from the zero position, the bias level is decreased farther, the control tubes conduct for a longer period of time during each half of the 400-cycle ac inputs, and the average current through the armature of the motor increases and the speed of antenna rotation increases.

d. Transformer T703 samples the average current through V701 and V702 applies a voltage proportional to the average current (and therefore proportional to the speed of antenna rotation) to full-wave rectifier V704. Three outputs are taken from V704. One is applied as a current feedback to the servo amplifier control circuits. This current feedback, in conjunction with voltage feedback directly from the drive motor armature, provides speed stability of antenna rotation. An output from V704 is applied to temporary overload V703B. If a momentary overload condition occurs, conduction of V703B causes more control rectifier bias to be developed and less driving power is applied to B751 to prevent damage to the drive motor. An output from V704 is also applied to sustained overload V706. If an overload condition occurs and is sustained for more than 5 seconds, V706 conducts and disables the effect of V703A so that the drive motor armature current is reduced to a safe value until the ANTENNA ROTATE hand wheel is returned to the zero rpm position.

82. Antenna Drive Assembly
(fig. 40)

The antenna drive assembly consists of an-

tenna drive motor B751 and a reduction gear assembly which provides for proper speed of rotation of the antenna and synchro transmitters with respect to the drive motor speed.

a. Constant field excitation is applied to B751 from bridge rectifier CR701 in the servo amplifier. Direction and speed of antenna rotation is controlled by controlling the amount and direction of armature current furnished by the servo amplifier.

b. Synchro data (400 cycles) are applied from the stator windings of B752 to the stator windings of synchro receiver B602 in the indicating system to make the ppi sweep follow antenna rotation.

c. Synchro data (60 cycles) are applied from the stator windings of B753 to the stator windings of a synchro receiver in the remote ppi unit to make the remote ppi sweep follow antenna rotation. Because only 400-cycle ac power is available within the equipment, 60-cycle ac excitation must be applied to the rotor of B753 from the remote ppi unit when used.

Section IX. AC POWER DISTRIBUTION AND CONTROL SYSTEM

83. General
(fig. 40)

The ac power distribution and control system controls the distribution of 115-volt, single phase, 400-cycle, ac power to all components in the equipment which require 115 volts ac directly, such as the primaries of transformers, blower motors, heaters, synchro rotors, relay, and indicating lamps.

a. Some of the distribution of ac power to the equipment is controlled by relays which require +27 volts dc to energize them. The +27-volt dc power is distributed also to the local oscillator filament circuit and to the local oscillator tuning motor in the receiving system.

b. All fuses, relays, and switches which affect the application of ac power or +27-volt dc power to the equipment are part of the ac power distribution and control system.

c. Four types of power are distributed by the ac power distribution and control system: undelayed +27 volts, delayed +27 volts, undelayed 115 volt ac, and delayed 115 volt ac.

84. Ac Power Distribution
(fig. 40)

Power is applied to the ac power distribution and control system from the primary source of power. When the system POWER switch is placed in the ON position, undelayed 115 volts ac is applied to all systems of the equipment, including the +27-volt power supply within the ac power distribution and control system.

a. The +27-volt power supply furnishes undelayed +27 volts to the receiving system and to the 5-minute time-delay circuit within the ac power distribution and control system.

b. After a time delay of 5 minutes, delayed +27-volt power is applied to control circuits in the receiving system, the signal comparing system, the transmitting system, the rf system, and the antenna positioning system, as well as to relays K152 and K705 which control the distribution of delayed 115 volts ac to the transmitting system and the antenna positioning system.

Section X. DC POWER SUPPLY SYSTEM

85. General
(fig. 40)

The dc power supply system receives 115-volt, 400-cycle power from the power distribution and control system and provides dc operating potentials for the entire equipment. The potentials furnished by the dc power supply system are—

a. Unregulated +450 volts to the indicating system.

b. Regulated +300 volts to the indicating, receiving, and transmitting systems.

c. Regulated +150 volts to the antenna positioning, indicating, receiving, and signal comparing systems.

d. Regulated —150 volts to the indicating, receiving, and signal comparing systems.

86. Dc Power Supplies
(fig. 40)

The dc power supply system furnishes plate

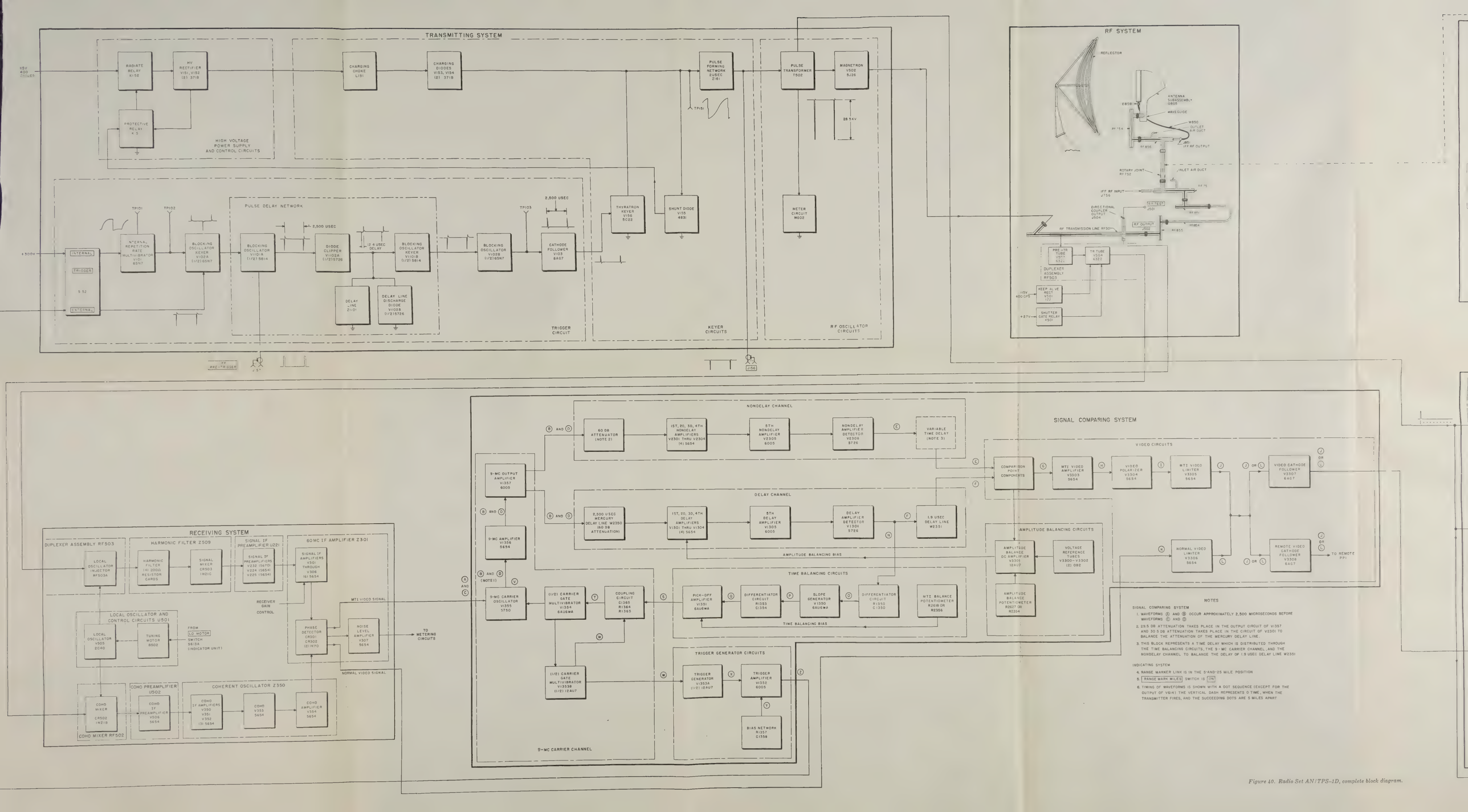


Figure 40. Radio Set AN/TPS–1D, complete block diagram.

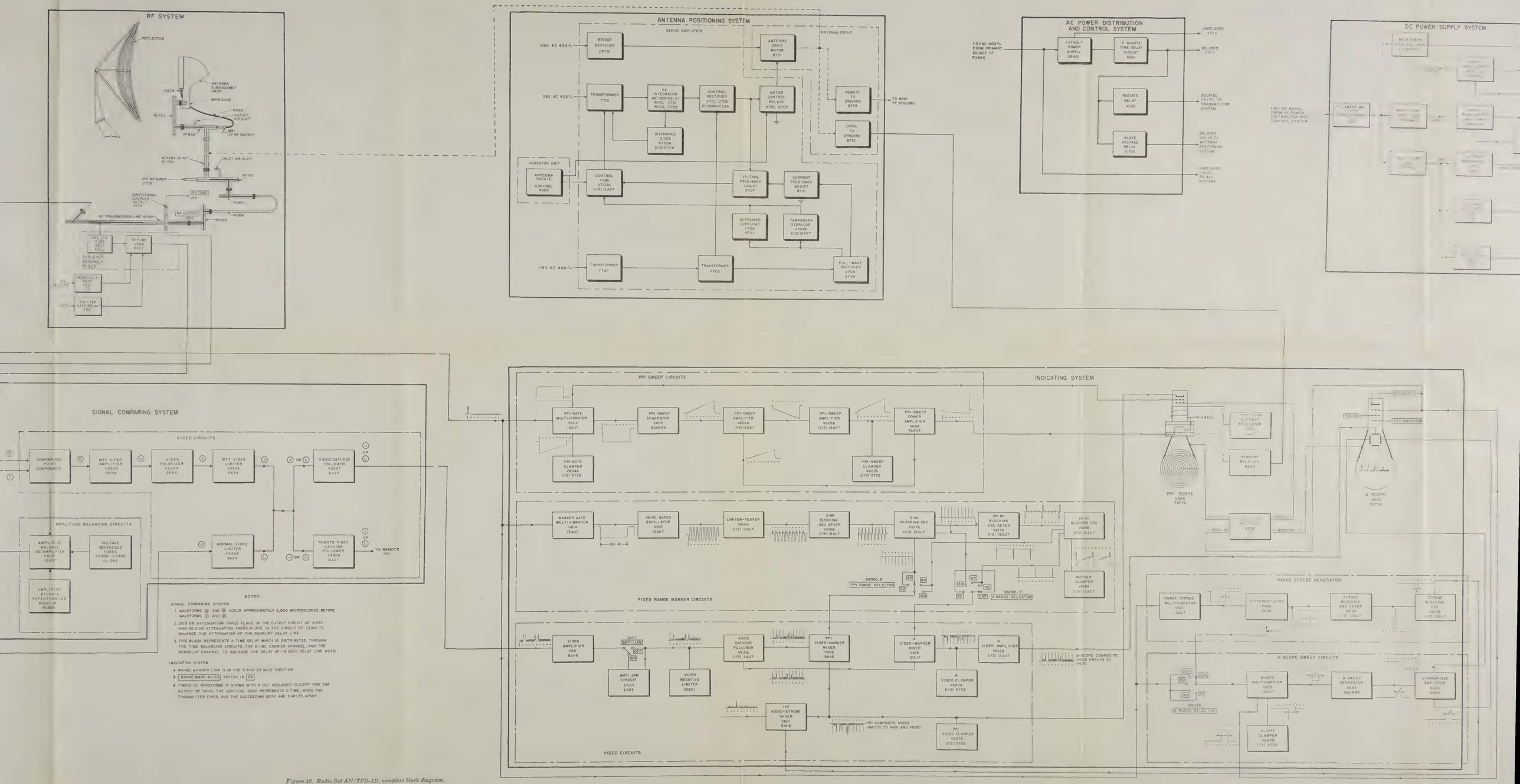
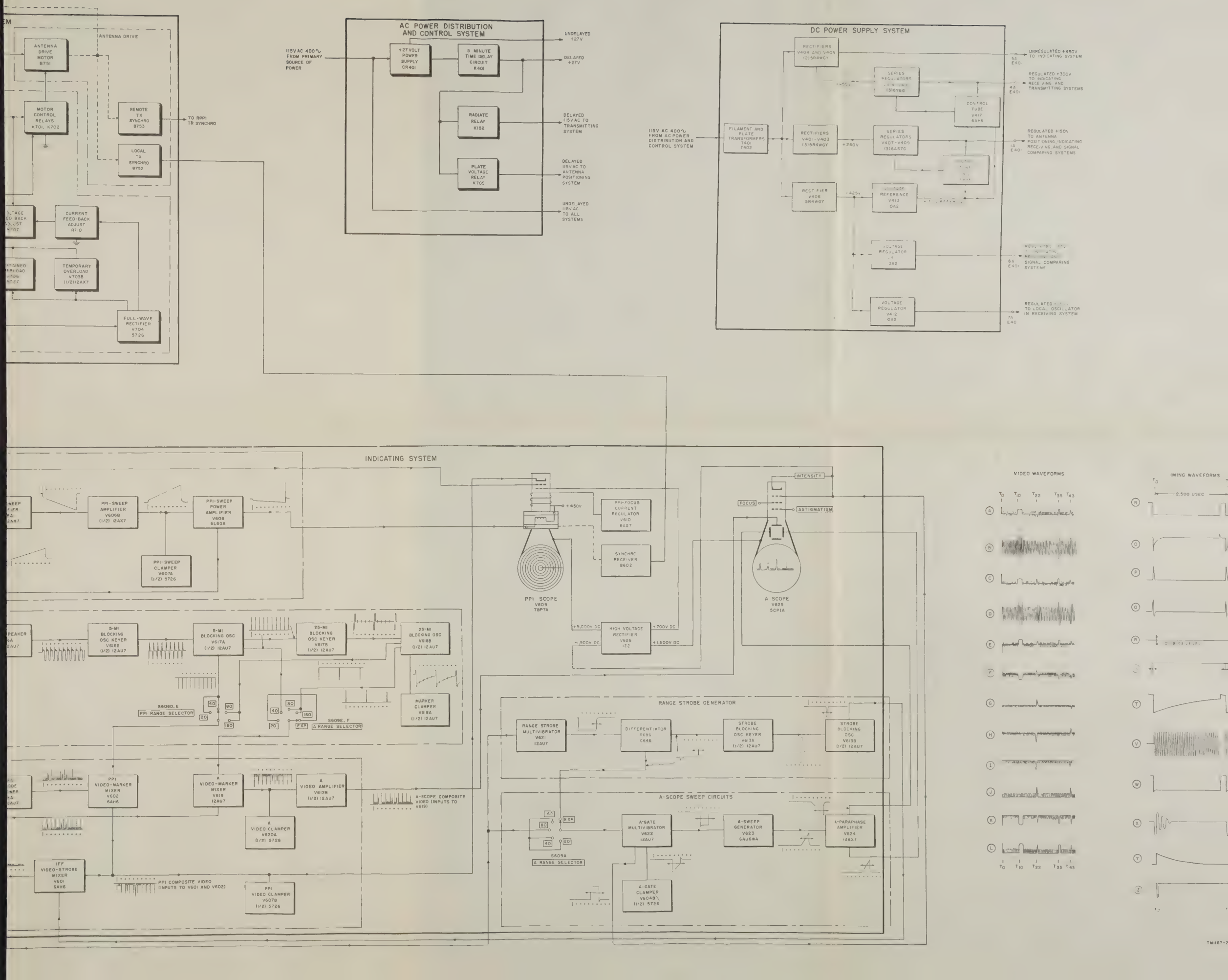


Figure 40. Radio Set AN/TPS–1D, complete block diagram.



ANTENNA DRIVE
ANTENNA DRIVE MOTOR B751
MOTOR CONTROL RELAYS K701, K702
REMOTE TX SYNCHRO B753
TO RPPI TR SYNCHRO
LOCAL TX SYNCHRO B752
CURRENT FEED-BACK ADJUST R710
TEMPORARY OVERLOAD V703B (1/2)12AX7
FULL-WAVE RECTIFIER V704 5726
AC POWER DISTRIBUTION AND CONTROL SYSTEM
115V AC 400~ FROM PRIMARY SOURCE OF POWER
+27 VOLT POWER SUPPLY CR401
5 MINUTE TIME DELAY CIRCUIT K401
RADIATE RELAY K152
PLATE VOLTAGE RELAY K705
UNDELAYED +27V
DELAYED +27V
DELAYED 115V AC TO TRANSMITTING SYSTEM
DELAYED 115V AC TO ANTENNA POSITIONING SYSTEM
UNDELAYED 115V AC TO ALL SYSTEMS
DC POWER SUPPLY SYSTEM
115V AC 400~ FROM AC POWER DISTRIBUTION AND CONTROL SYSTEM
FILAMENT AND PLATE TRANSFORMERS T401 T402
RECTIFIERS V404 AND V405 (2)5R4WGY
RECTIFIERS V401-V403 (3)5R4WGY
RECTIFIER V406 5R4WGY
SERIES REGULATORS 1316Y6G
CONTROL TUBE V417 6AH6
SERIES REGULATORS V407-V409 (3)6AS7G
REFERENCE V413 OA2
VOLTAGE REGULATOR OA2
VOLTAGE REGULATOR V412 OA2
+260V
-425V
UNREGULATED +450V TO INDICATING SYSTEM
REGULATED +300V TO INDICATING RECEIVING AND TRANSMITTING SYSTEMS
REGULATED +150V TO ANTENNA POSITIONING, INDICATING RECEIVING, AND SIGNAL COMPARING SYSTEMS
SIGNAL COMPARING SYSTEMS
TO LOCAL OSCILLATOR IN RECEIVING SYSTEM
INDICATING SYSTEM
PPI-SWEEP AMPLIFIER V606B (1/2) 12AX7
PPI-SWEEP POWER AMPLIFIER V608 6L6GA
PPI-SWEEP CLAMPER V607A (1/2) 5726
PPI-FOCUS CURRENT REGULATOR V610 6AG7
SYNCHRO RECEIVER B602
PPI SCOPE V609 7BP7A
HIGH VOLTAGE RECTIFIER V626 122
+450V
+5,000V DC
-1,500V DC
+700V DC
+1,500V DC
INTENSITY
FOCUS
ASTIGMATISM
A SCOPE V625 5CP1A
5-MI BLOCKING OSC KEYER V616B (1/2) 12AU7
5-MI BLOCKING OSC V617A (1/2) 12AU7
25-MI BLOCKING OSC KEYER V617B (1/2) 12AU7
25-MI BLOCKING OSC V618B (1/2) 12AU7
MARKER CLAMPER V618A (1/2) 12AU7
S606D, E PPI RANGE SELECTOR
S609E, F A RANGE SELECTOR
PPI VIDEO-MARKER MIXER V602 6AH6
A VIDEO-MARKER MIXER V619 12AU7
A VIDEO AMPLIFIER V612B (1/2) 12AU7
A VIDEO CLAMPER V620A (1/2) 5726
A-SCOPE COMPOSITE VIDEO (INPUTS TO V619)
IFF VIDEO-STROBE MIXER V601 6AH6
PPI COMPOSITE VIDEO (INPUTS TO V601 AND V602)
PPI VIDEO CLAMPER V607B (1/2) 5726
RANGE STROBE GENERATOR
RANGE STROBE MULTIVIBRATOR V621 12AU7
DIFFERENTIATOR R686 C646
STROBE BLOCKING OSC KEYER V613A (1/2) 12AU7
STROBE BLOCKING OSC V613B (1/2) 12AU7
A-SCOPE SWEEP CIRCUITS
S609A A RANGE SELECTOR
A-GATE MULTIVIBRATOR V622 12AU7
A-SWEEP GENERATOR V623 6AU6WA
A-PARAPHASE AMPLIFIER V624 12AX7
A-GATE CLAMPER V604B (1/2) 5726
VIDEO WAVEFORMS
IMING WAVEFORMS
2,500 USEC

supply potentials to most of the stages and bias potentials to many of the stages in the equipment. For this reason, the dc power supply system incorporates a protective feature which prevents the application of plate supply potentials when bias potentials are absent due to trouble in the negative portion of the dc power supply system.

a. Power is applied to filament transformer T401 and plate transformer T402 from the ac power distribution and control system. Filament transformer T401 furnishes filament power to positive rectifiers V401 through V405 and to negative rectifier V406. Plate transformer T402 furnishes different values of stepped-up ac potentials to all three rectifier circuits which are operated as conventional full-wave rectifier circuits. Each rectifier has a choke input-type filter associated with it to smooth out the 800 cycles ripple frequency. Parallel rectifier tubes are used in the positive power supplies due to the larger load currents furnished by them.

b. Rectifiers V404 and V405 furnish unregulated +450 volts to the ppi-sweep amplifiers and the ppi focus current regulator. This is done because the relatively large currents cannot be handled by the indicator high-voltage power supply. Plus 450 volts is also applied to the +300-volt voltage regulator circuit which consists of series regulators V414 through V416 and control tube V417. The output from the +300-volt voltage regulator is applied to many stages in the indicating, receiving, and transmitting systems.

c. The +300-volt voltage regulator regulates for changes in the line voltage applied from the ac power distribution and control system as well as for changes in load current which would normally cause a change in output voltage. Either tendency for the output regulated +300 volts to change causes the input to the control tube to change. The control tube acts as a dc amplifier and causes the bias on the series-regulator tubes to vary. The change in bias causes the dc resistance of the series-regulator tubes to vary so that the change in voltage across the series-regulator tubes allows the output voltage to remain very close to +300 volts.

d. Positive rectifiers V401 through V403 apply approximately +260 volts to the +150-volt voltage regulator which consists of series regulators V407, V408, and V409 and control tube V410. The +150-volt voltage regulator functions the same as the +300-volt voltage regulator so that the regulated +150 volt output to the antenna positioning, indicating, receiving, and signal comparing systems is held very close to +150 volts.

e. Negative rectifier V406 furnishes unregulated —425 volts to voltage regulators V411 and V412 and to voltage reference tube V413. All three stages operate as shunt regulators, their output voltage being regulated at —150 volts. The output from V411 (regulated —150 volts) is applied to the indicating, receiving, and signal comparing systems where it is used for establishing bias potentials. The output from V412 is applied to the receiving system where it is used as B-minus for the local oscillator stage.

f. The output from voltage reference tube V413 is applied to the +150-volt and +300-volt voltage regulator circuits where it is used to maintain a constant reference voltage for proper operation of the voltage-regulator circuits. This arrangement provides for protection of the equipment by preventing the application of normal B+ potentials when the negative rectifier circuit becomes inoperative and bias potentials are lost. If there is no output from negative rectifier V406, the normal regulated +300-volt output (4A) is reduced to approximately +100 volts and the normal regulated +150 volt output (1A) is reduced to approximately +100 volts.

CHAPTER 5
SHIPMENT AND LIMITED STORAGE AND DEMOLITION TO PREVENT ENEMY USE

Section I. SHIPMENT AND LIMITED STORAGE

87. Disassembly

The radar set must be disassembled prior to preparing it for shipment or limited storage. The disassembly procedure to be used is covered in paragraphs 85 through 88, TM 11–1167–10.

88. Repackaging for Shipment or Limited Storage

a. General. The set may be damaged during shipment if it is carelessly or inadequately repackaged after being used in the field. Damage can be caused by physical shock because of poor packing techniques. This section presents methods for organizations responsible for field repackaging of the sets for zone of the interior and intertheater shipment. Exact procedures for repackaging depends on the material available and the conditions under which the equipment is to be shipped or stored. Use the procedures described whenever possible.

b. Zone of Interior Shipment. Transit cases for all the components have been designed to furnish adequate protection for their contents under most conditions of zone of the interior or domestic shipment. Motor transport usually will be used for such shipments, and wooden cases are not required. Preparations and procedures for shipment by motor transport are fully covered in paragraphs 85 through 88, TM 11–1167–10.

c. Intertheater Shipment. If the equipment is to be shipped into another theater, overseas, or to a distant place by means other than motor transport, repacking in wooden cases is required. Use the original wooden packing cases if available.

d. Materials Required. The following materials are required for repacking the set. For stock numbers of the materials, refer to SB 38–100, Preservation, Packaging and Packing Materials, Supplies, and Equipment Used in the Army.

Material	Quantity
Waterproof paper	450 sq ft
Waterproof tape	200 ft
Corrugated cardboard	450 sq ft
Filler material	50 lb
Strapping, flat steel 5/8 x .020	900 ft
8d nails	25 lb
Wooden shipping boxes (see TM 11–1167–10 for dimension of boxes).	13

e. Packaging. All the units should be packaged carefully. Cushion each unit on all surfaces with pads of corrugated cardboard. Place the cushioned unit within a wrap of waterproof paper. A desiccant should be placed within the unit and within the wrap, if available. Secure the wrap with waterprof tape.

f. Packing. Pack each of the packages in separate nailed wooden boxes. For a typical crating illustration that can be used as a model, refer to figure 21, TM 11–1167–10. Make the boxes so the contents fit snugly and line them with a waterproof liner. Use waterproof tape to close the liner. Fill any voids with corrugated paper. There should be at least 3 inches of excelsior or filler material between the paper barrier and the packing case. Place metal strapping around the boxes.

g. Marking. Mark the shipping boxes in accordance with the requirements of SR 55–720–1, section II, Transportation and Travel, Preparation for Oversea Movement of Units (FOM).

h. Limited Storage. When the set is to be stored for a limited time, follow the procedures below.

(1) Take a complete inventory of all components, tools, spare parts, and test equipment to make sure that the radar set is complete and serviceable. Unserviceable parts or components should be repaired or replaced.

(2) Make sure that the oil is drained from the antenna base and that the set is greased as directed in paragraph 22.

(3) Thoroughly clean the set. Use a clean cloth to remove the dust, dirt, moisture, and grease. If necessary, wet the cloth with cleaning compound and clean the parts; then wipe with a dry, clean cloth. In addition, refer to paragraph 74, TM 11–1167–10 for special cleaning procedures.

(4) Touch up and refinish all rust spots. Clean the rust spot with medium-fine sandpaper. Wipe the area clean and apply one coat of zinc-chromate primer (spec. Jan–P–735; stock No. 52–P–2063–2, 1-gal size). Then apply two finish coats of paint (spec. 52–E–12).

(5) Check the tropicalization of the internal surfaces. If there are scratches and abrasions, clean the surface of dirt, oil, or grease. Apply an even film of varnish. The only varnish to be used should be approved under Signal Corps spec. 71–2202A and Jan–C–173, or MIL–V–173.

(6) Cover the equipment with canvas tarpaulins, if available.

Section II. DEMOLITION OF MATERIEL TO PREVENT ENEMY USE

89. Authority for Demolition

The demolition procedures given in paragraph 92 should be used to prevent the enemy from using or salvaging this equipment. Demolition of the equipment will be accomplished only upon the order of the commander.

90. Destruction Plan

If a destruction plan is not provided by higher authority, one should be prepared by the organization using the equipment. In this plan, personnel should be assigned to specific destruction tasks so that minimum time will be required should destruction of the radar set become necessary. All concerned personnel in the using organization should be familiar with all aspects of the complete destruction plan. The plan must be complete and adequate and easily carried out in the field and must provide for destruction as complete as available time, equipment, and personnel will permit under various circumstances. Because the time required for complete destruction may not always be available, the destruction plan must establish priorities so that essential parts of the equipment will be destroyed in the order of their importance. Systematic destruction of the same important units of equipments of a given type will prevent the enemy from learning the important features of the equipment and also will insure against the assembly of a complete equipment by the enemy through cannibalization or combination of partially destroyed equipments. Adequate destruction of some units of the equipment should always be accomplished in preference to partial destruction of all the units. Which of the methods of destruction, listed in paragraph 92, are to be used depends on the time allowed for the destruction to be carried out.

91. Destruction Priority

Destruction priority in the following order is suggested for Radio Set AN/TPS–1D.

a. Highest priority should be given to instruction literature, to operating units and spare parts that might disclose the operating frequency of the set, and to the critical circuitry and spare parts of the signal comparator unit.

(1) The frequency sensitive parts of the AN/TPS–1D to be considered are; the magnetron, the local oscillator, the coho mixer, the signal mixer, and the RF sections and fittings in the receiver-transmitter unit; the RF lines and fittings on the antenna base, those between the antenna base and the receiver-transmitter unit, and those between the antenna base and the antenna; and the antenna assembly, particularly the antenna horn.

(2) The circuitry in the signal comparator unit, particularly the mercury delay

line, shares top destruction priority with the frequency sensitive parts of the equipment.

b. The modulator unit, which might disclose the power potential of the equipment, is next in order of priority.

c. The portions of the receiver-transmitter unit not destroyed (*a*(1) above), the power supply, indicator, antenna base units, and the power source (if a field power unit is used) should be destroyed in the above order after destruction of the modulator.

d. If spare parts other than those specified in *a* above cannot be destroyed as one destruction item, the individual parts should be destroyed in the same order as the units for which they are supplied.

92. Methods of Destruction

Any or all of the methods of destruction given below may be used. The time available will be the major determining factor for the methods to be used in most instances. The tactical situation also will determine in what manner the destruction order will be carried out. For instance, when speed is imperative, destruction by burning or by use of explosives might be undertaken and all other methods ignored. If there is sufficient time and it is desirable to keep the location of the equipment hidden from the enemy as long as possible, all other methods of destruction might be used first and fire or explosives used to complete destruction only immediately before withdrawal. In any case, it is mandatory to destroy completely some portions of the equipment rather than to partially destroy all of the equipment units.

a. Preliminary. Destruction of the equipment can best be accomplished if the units of the set are separated. To prepare the set for destruction, proceed as follows:

Note. Subparagraphs (1) through (5) below apply to the single stack installation. The same general procedures should be adapted for other installations using tents as shelters.

(1) Remove the retaining pins from the corners of the four lower units of the stack.

(2) Remove the tent shield, open the tent from top to bottom, pull the tent stakes and the tent fly stakes, and cut or disconnect the guy cables.

(3) Pull the tent around the stack to expose the rear of the stack, and push the stack over so that the units will fall to the ground with the front panels upward.

(4) Roll the tent to the top of the equipment stack and pull the retaining pins that fasten the two upper units together at the corners.

(5) After the interconnecting cables and straps have been cut (*b* below), move the five lower units of the stack away from the assembled antenna and antenna base unit and separate the units enough to allow free movement of personnel destroying each unit.

b. Cut. Use axes, handaxes, machetes, etc to cut cabling and cording in and on the equipment. Use cutting pliers or shears to cut the interunit ground straps and the ground cable.

(1) Cut the interunit ground straps and the ground cable.

(2) Cut the unit interconnecting cables within a few inches of each end and in at least one other place along the cable length.

(3) Cut the coaxial line (RF854) from between the antenna base and the receiver-transmitter unit and lay it to one side to be burned or buried.

(4) Separate the units (*a*(5) above) and stand them upright. Withdraw the unit chassis from their cases and cut all readily accessible internal cables and cabling harnesses.

(5) Cut all spare cables.

c. Smash. Use sledges, axes, hammers, crowbars, and other heavy tools, and rifle butts, if necessary, to smash both the interior and exterior of the equipment units.

(1) On the front panels, smash all cable connectors (with the cable ends attached), all controls and fuse holder projections, and all instruments (meters and dial faces).

(2) Smash the RF lines and fittings on the receiver-transmitter, antenna base, and

antenna, and remove the line sections. Lay the RF line sections to one side to be buried.

(3) Use a heavy sledge to smash, as much as possible, the antenna base unit and the antenna assembly, particularly the antenna horn. Try to knock out of line or bend the spindle on the antenna base unit.

(4) In the receiver-transmitter unit, make sure that the RF portion of the unit is thoroughly demolished. Force the magnetron from its mounting with a crowbar or a bar and sledge. Smash the magnetron with a sledge and lay it to one side to be buried or otherwise disposed of.

(5) If possible, remove and smash all of the RF components in the receiver-transmitter unit in the same mnaner as the magnetron ((4) above).

(6) Remove the signal comparator unit from its case and remove the main chassis from the unit. Break the delay network from its mounting and use a heavy sledge to smash the delay line and its case. Set the delay network to one side to be buried.

(7) Destroy the tubes in the modulator unit and use a sledge or crowbar to break open and smash the large capacitors and transformers and the pulse line.

(8) Smash the A-scope and ppi-scope tubes.

Warning: To minimize the risk of injury, push the indicator unit into its case and stand to one side of the unit to smash the scope tubes.

(9) With all unit chassis withdrawn from their cases, smash all tubes and other top-of-the-chassis parts. Turn the units over and smash the circuit parts on the undersides of the chassis.

Warning: Provide adequate protection against flying glass when smashing the tubes in the equipment units.

(10) If fire or explosives are not to be used for completion of the destruction, replace the units in their cases and with a heavy sledge, bend the front panels and the sides of the cases so that the units cannot be pulled from the cases.

d. Burn. Gasoline, flame throwers, or other incendiary devices may be used to destroy the equipment, only upon direction of competent authority.

(1) Burn the instruction literature; use whatever incendiary material is available to insure complete destruction.

Note. If time permits, remove the magnetron from the receiver-transmitter unit and the delay line from the signal comparator unit before attempting to burn the equipment.

(2) The cases in which the equipment chassis are mounted are made of metal containing magnesium. These cases will burn if sufficient heat is applied to them. The heat generated when these cases burn will effectively destroy the chassis and circuitry of the units within the cases. Pour gasoline over the cases and ignite it.

Warning: Be extremely careful when applying fire to the equipment. The equipment cases, when ignited, burn almost spontaneously and emit intense heat.

(3) Burn the cut cables and the spare parts by pouring gasoline over them and igniting it or by using flame throwers.

Note. If time is not available for detailed destruction to be undertaken, the equipment may be destroyed by pouring gasoline on and around the equipment stack and igniting it. This method of destruction should be used only when a specific order is issued at the equipment site.

e. Explode. Explosives may be used to complete destruction of the equipment or to affect maximum damage prior to burning when time does not permit complete destruction by other means. Powder charges, fragmentation grenades, thermite bombs, or incendiary grenades may be used. Thermite bombs or incendiary grenades will be most effective for destroying this radar set. Regardless of the completeness of destruction afforded by explosives, if time permits, it is desirable to remove and dispose of the frequency-sensitive parts and circuitry (particularly the magnetron) and the mercury delay line.

Warnings:

1. The use of small arms fire for destruction of equipment should be avoided. Such fire exposes personnel to the danger of ricochets.
2. Explosives should be used only on direct order of the Officer or NCO in charge at the equipment site. They should be used only by or under the direct supervision of personnel thoroughly trained to handle them.
3. Make sure that adequate cover is available and that sufficient time is allowed for personnel to take cover when explosives are to be used to destroy the equipment.

(1) When the equipment units are dismantled and separated and explosives are to be used for destruction, use one explosive charge (preferably a thermite bomb or incendiary grenade) for each unit. A thermite bomb or incendiary grenade should generate enough heat so that the unit cases will be ignited as well as being shattered by the explosion.

(2) Warn other personnel to take cover. Pull the unit to be destroyed part of the way out of its case. Pull the pin on the bomb or grenade, place the explosive in the unit case, push the unit back into the case and take cover quickly.

(3) If time does not permit dismantling the equipment and separating the equipment units for destruction, and the equipment must be destroyed while still stacked, use the following procedures.

(*a*) For a single stack installation, pour gasoline on and around the equipment stack. Pull the receiver-transmitter unit, the signal comparator unit, and the modulator unit (the bottom unit of each stack) part way out of their cases. Place incendiary devices in the three units simultaneously, push the units back into their cases, and take cover quickly.

(*b*) For multiple stack installation, pour gasoline on and around the equipment stacks and place incendiary (or explosive) devices in at least one unit of each stack simultaneously. Make sure that adequate provision is made for destruction of the receiver-transmitter unit and the signal comparator unit.

f. Disposal. Bury or scatter destroyed parts or throw them into nearby waterways. Pay particular attention to frequency-sensitive parts of the equipment (magnetron, local oscillator assembly, RF lines and plumbing, etc) and the delay line. Do not dispose of parts intact; smash or otherwise destroy all critical parts at least partially before disposing of them.

APPENDIX
REFERENCES

Following is a list of references applicable and available to the second echelon personnel of Radio Set AN/TPS–1D:

FM 11–151	Defense Against Electronic Jamming.
FM 44–7	Electronic Search Central AN/GSS–1 and Radar Set AN/TPS–1D.
TB SIG 227	Radar Data Plotting Board PT–171/TPS.
TM 11–337	Telephone Sets TA–43/PT and TA–263/PT.
TM 11–467	Radar System Fundamentals.
TM 11–671	Cathode-Ray Tubes and their Associated Circuits.
TM 11–673	Generation and Transmission of Microwave Energy.
TM 11–675	R-F Transmission Lines.
TM 11–750	Radar Antijamming for the Operator.
TM 11–751	Radar Antijamming for the Technician.
TM 11–759	Theory and Measurement of Pulse Radar System Performance.
TM 11–910	Motor Generator Set PU–126/U.
TM 11–919	Gasoline Engine Generator Set PU–107/U.
TM 11–1162	Radar Surveillance Central AN/GSS–1.
TM 11–1190	Interrogator Set AN/TPX–19.
TM 11–1250	Test Set AN/MPM–23.
TM 11–1262	Test Set TS–172A/UP.
TM 11–5112	Azimuth and Range Indicator IP–345/TPS–1D.
TM 11–5128	Summation Bridge AN/URM–23 Operating, Service, and Overhaul Instructions.
TM 11–5553	Signal Generator TS–419/U Maintenance Instructions.

GLOSSARY

1. Abbreviations

Ac —Alternating current
Cps —Cycles per second
Cw —Continuous wave
Db —Decibel
Dc —Direct current
IF —Intermediate frequency
Iff —Identification friend or foe
Mc —Megacycles
Mti —Moving target indicator (indication)
Prf —Pulse repetition frequency
Ppi —Plan position indicator (indication)
RF —Radio frequency
Rpm —Revolutions per minute
Tr —Transmit and receive
μ —Micro

2. Definitions

Antenna reflector—That portion of a directional array, frequently indirectly excited, which reduces the field intensity behind the array and increases it in the forward direction.

A scope—An indicator with a horizontal sweep, giving range only. Signals appear as deflections on the time scale.

Bolometer—A power sensitive device for making minute power measurements.

Blocking oscillator—A type of relaxation oscillator used as a pulse generator in radar equipments.

Cathode follower—A vacuum-tube circuit in which the input signal is applied between the control grid and ground, and the output is taken from the cathode and ground. A cathode follower has a high input impedance and a low output impedance.

Clamper—A circuit which maintains either amplitude extreme of a waveform at a certain level of potential.

Coaxial cable—A transmission line consisting of two conductors concentric with and insulated from each other.

Coherent (coho) oscillator—A stable reference oscillator that is matched in phase with the transmitted pulse by a RF locking pulse from the transmitter.

Delay line—Usually an artificial transmission line used to introduce a short time delay in the transfer of a signal from one circuit to another.

Differentiator—A reshaping circuit that produces an output voltage that is proportional to the rate of change of the input voltage. It transforms a square pulse into a sharp voltage spike.

Duplexer—Combination of transmit-receive switch, and sometimes an anti-transmit-receive switch, with transmission lines, which enables the same antenna to be used for both transmitting and receiving.

Echo signal—The portion of the energy of the transmitted pulse which is reflected back to the source by a target.

Gate—A square-voltage wave which switches a circuit on or off electronically, usually by application to a grid or cathode.

Horn radiator—Any open-ended metallic device for concentrating energy from a waveguide and directing this energy into space.

Iff system—A system incorporated in a radar set to determine whether airplanes are friend or foe.

Interlock—A switch placed in the door of a cabinet, which must be closed before this switch will make contact and permit the high-voltage to be thrown on.

Integrator—A wave-shaping circuit which produces an output voltage substantially in proportion to the frequency and amplitude of the input voltage. When a rectangular or trapezoidal waveform is applied to an integrator circuit, the output is a sawtooth or triangular wave.

Jamming—Intentional interference with normal operation of radio communication or radar equipment.

Keep-alive—An auxiliary electrode in the transmit-receive switch, to which a negative dc potential is applied. The keep-alive is turned on before the main RF power, and furnished sufficient ions for almost instantaneous discharge across the main gap with small leakage power to the crystal.

Local oscillator—The oscillator used in a superheterodyne receiver of a radar set, the output of which is mixed with the desired RF carrier to form the intermediate frequency.

Magnetron—A transmitter tube which produces the main pulse of ultra-high frequency energy. The flow of electrons is controlled by an applied magnetic field.

Mixer—A vacuum tube or crystal and suitable circuit used to combine the incoming and local-oscillator frequencies to produce an intermediate frequency.

Modulator—The part of the radar set which controls the application of plate voltage to the transmitter.

Multivibrator—A form of relaxation oscillation, essentially a two-stage amplifier with feedback. Will oscillate of its own accord, or as a result of the application of an external synchronizing voltage.

Nautical miles—To convert nautical miles into statute miles multiply by 1.1516; conversely, multiply by .8684 to convert statute miles into nautical miles.

Paraphase amplifier—An amplifier which converts a single input into a push-pull output.

Potentiometer—A variable voltage divider; a resistor which has a variable contact arm so that any portion of the potential applied between its ends may be selected.

Ppi scope—Plan position indicator. The sweep is a radius of the tube face (from center of face), and moves around 360°. It gives azimuth by direction of the radial line, and range by the distance of the signal from the center of the screen.

Pulse-forming line—A combination of inductors and capacitors used to produce a square pulse of controlled duration.

Pulse repetition rate—The rate (usually given in cycles per second) at which pulses are transmitted from the radar set.

Pulse transformer—A special transformer designed to have a frequency response suitable for passing a pulse without materially altering its shape.

Range mark—A mark on the ppi screen which indicates distances from the radar of the various echoes appearing on the screen of scope.

Rectifier—A device used to change alternating current to unidirectional current.

Servo—A complete electromechanical system for amplifying and transmitting accurate mechanical position from one point to another by electrical means.

Slant range—The straight-line distance from the radar set to the target. Used in contrast to ground range.

Synchro—A single-phase self-synchronous machine which converts mechanical position into electrical signal, or vice versa.

Time base—Trace produced on the screen of a cathode-ray tube by linear deflection of the electron beam. In radar, the time measured along the sweep is proportional to range since it normally starts with the beginning of the transmitter pulse. In some circuits the beginning of the sweep is delayed for a fixed or variable time after the firing of the transmitter. It is then known as a delayed sweep.

Thyratron—A hot-cathode, gas-discharge tube in which one or more electrodes are used to control electrostatically the starting of an unidirectional flow of current.

Trigger pulse—A pulse which starts a cycle of operation.

Tr switch—Transmit-receive switch. A switch which prevents the transmitted energy from getting to the receiver, but allows the received energy, which is much weaker, to reach the receiver without appreciable loss. This is necessary when the same antenna is used for both transmission and reception.

Video—The intelligence of a radar echo.

Video amplifier—An amplifier which has uniform response to signals of a very wide band of frequencies.

Waveguide—A hollow pipe, usually of rectangular or round cross section used to transmit RF energy. The dimensions of the pipe are determined by the wavelength to be transmitted.

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NG: State AG; units—same as Active Army.

USAR: None.

For explanation of abbreviations used, see AR 320–50.

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